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A Cost-Benefit Analysis of Public Law 99-625: Sea Otter-Shellfishery Conflicts in Santa Barbara and Ventura Counties

A Group Project submitted in partial satisfaction of the requirements for the degree of
Master's in Environmental Science and Management
for the
Donald Bren School of Environmental Science & Management

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The Group Project is required of all students in the Master's of Environmental Science and Management (MESM) Program. It is a three-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Final Group Project Report is authored by MESM students and has been reviewed and approved by:

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EXECUTIVE SUMMARY

Conflicts between fisheries and marine mammals are increasing in frequency. These include increasing discord between federal and state protection of the southern sea otter (*Enhydra lutris nereis*) and shellfisheries in California. Congress enacted Public Law 99-625 (P.L. 99-625) in 1986 in an effort to provide the threatened sea otters with a safeguard from catastrophic oil spills and limit conflict with fisheries. Currently the U.S. Fish and Wildlife Service (USFWS) is not relocating otters and is advocating declaring the translocation plan within P.L. 99-625 a failure. This report examines the economic impact of the southern sea otter with and without enforcement of containment and translocation under P.L. 99-625. The focus area of this report is the coastal waters of Santa Barbara and Ventura Counties, including the Channel Islands. Impacts are projected from 2001 to 2025.

We assumed that the largest quantifiable costs of continued enforcement would be the costs of translocation, whereas the largest quantifiable economic impacts of allowing the otter population to expand would be to fisheries and to tourism. We used a spatially explicit population model to project the growth of the otter population in the absence of zonal management. Using data on otter diet preferences we projected shellfish consumption by otters. An econometric model of the otter's impacts to shellfisheries was developed to estimate the economic of lost fisheries due to otter consumption of key prey items. We analyzed California tourism data from 1990-97 to estimate the tourism benefit of a local otter population and used this data to project the impacts that otters will have on Santa Barbara and Ventura Counties' tourism revenues.

A cost-benefit analysis (CBA) was conducted to determine the most economically efficient of two management scenarios for the southern sea otter: (1) containment and translocation of sea otters under Public Law 99-625 or (2) natural sea otter range expansion with no translocation (status quo). The goal of this analysis is to provide a tool that can be employed within the policymaking framework of P.L. 99-625. The economic efficient policy option is to discontinue the sea otter translocation and allow natural range expansion. Continued translocation and containment would incur management costs of approximately $1,041,000 while the net benefits from allowing natural otter range expansion would be approximately $114,800,000 (net present value, assuming a 7% discount rate, using median otter population estimates).

Even if fisheries costs are estimated as the loss of income for fishers, which are 50% of lost revenues, this value (approximately $12 million net present value, assuming a 7% discount rate, using median otter population estimates) is still outweighed by the tourism benefits.

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SECTION 1: INTRODUCTION

The Pacific Rim supported approximately 150,000 to 300,000 sea otters (*Enhydra lutris*) prior to European hunting (Kenyon, 1969). Trade of sea otter pelts during the 18th and 19th centuries nearly eliminated the species from their historic habitat range that extended from Japan to Baja Mexico.

A few Alaskan remnant colonies in 13 locations were thought to be the only surviving populations at the turn of the 20th century (Kenyon, 1969). The population was thought to have been extinct in California until a small colony of about 32-50 individuals was discovered around the Big Sur area in 1938. Although the Alaskan population initially grew at a rate of 15-20% per year the California population has maintained an average annual increase of only 5% (Estes, 1990). The current range of the California sea otter expands from Half Moon Bay in the north to Gaviota in the south (USFWS, 2000).

THE SEA OTTER--FISHERIES CONFLICT

Because of potential devastation to the population in the event of an oil spill and a small population size, the California sea otters were listed as threatened in 1977 (See 42 Federal Register 2965; Final Rule 52 FR 29754-29790 (11Aug. 1987) and section 7 Endangered Species Act of 1973 as amended (ESA). The United States Fish and Wildlife Service (USFWS) determined that an experimental translocation program with zonal management was the most reasonable and effective recovery plan for the otter (Benz, 1996).

In 1982, the USFWS drafted the zonal management strategy within the Sea Otter Management Plan (Benz, 1996, Clark, 1996). The goal of this strategy was to establish a new otter colony outside existing range, and to prevent the otters from re-colonizing areas where substantial shellfisheries existed. In 1986, the translocation of sea otters to San Nicolas Island was authorized by Public Law 99-625 (P.L. 99625), which also prohibited otter range expansion south of Point Conception. Between 1987 and 1990, 139 otters were captured from various areas along the California coast and translocated to San Nicolas Island (for an expanded discussion of sea otter protection and management see Appendix G). For unknown reasons, many of the transferred otters subsequently left and the current population at San Nicolas Island remains constant at approximately 17 animals (USFWS 2000b). In the spring of 1998, about 100 otters were observed south of Point Conception, and in the spring of 1999, about 150 otters were observed south of Point Conception (USFWS 2000a). These otters have not yet established a permanent colony, but their presence has ignited a controversy over the current zonal management system.

The USFWS is cautious about capturing and relocating sea otters in the management zone for several reasons. Past experience with relocation has shown that otters return to the area where they were captured (USFWS, 2000b). Relocating large numbers of otters back to the area from which they have strayed would also increase competition for food resources in that area (Siniff and Ralls, 1991). Because of a variety of other factors, including the sensitivity of adult male otters to capture with potentially lethal results and the effects of relocation on otter family structure, attempts to move the otters may add to the current decline in the total sea otter population (Benz, 1996; Clark, 1996; Tinker *et al*, 2000; USFWS 2000b). To date, 12 southern sea otters are confirmed to have died as a result of either being captured, held, or transported during containment (USFWS, 2000b). The issue is complicated further by a change in the otter's status from steady growth to a recent decline. Although the last census shows a small increase in numbers for the population (USFWS unpublished data), it is uncertain if this is a trend.

Besides high removal costs and potential otter mortality with capture and release, there are two additional reasons for concern over the containment and translocation plan within P.L. 99-625 (Tinker *et al,* unpublished). First, based on the impacts of the *Exxon-Valdez* event, there are doubts that the translocation will actually achieve the goal of protecting the otter from catastrophic oil events, and second, there are concerns about population-level effects after translocation (Benz, 1996, Tinker *et al*, unpublished).

Fishermen want the otters removed to protect the shellfisheries while other groups maintain that the otter's natural range expansion should be allowed to continue. These groups maintain that the translocation effort has failed, thus the USFWS is not obligated to remove the otters. The fishermen, however, maintain that the translocation is a success and the USFWS is legally obligated to prevent otters from moving south of Point Conception. Recent developments in the conflict include the local fishery contingency filing a lawsuit against the U.S. Secretary of the

Interior and the USFWS. Concurrently the USFWS is drafting a supplemental environmental impact statement to determine the best management option for the sea otter. As management decisions are currently being formulated with regards to the sea otter, it is important to create a clear method for comparing different management options and their associated impacts on society and the nearshore environment. The goal of this project is to provide a tool to examine the efficacy of P.L. 99-625 and aid in the comparison of differing policy options through the use of a cost-benefit analysis.

STUDY OVERVIEW

An examination by cost-benefit analysis (CBA) provides a means of comparing complex policy options. Boardman et al (1996) list the CBA methods as:

1. Decide whose benefits and costs count.
2. Select alternative options.
3. Catalogue potential impacts.
4. Predict quantitative impacts over the life of the project.
5. Monetize all impacts.
6. Discount to find present values.
7. Add up the benefits and costs.
8. Perform a sensitivity analysis.
9. Recommend the alternative with the largest net social benefits.

We conducted a cost-benefit analysis (CBA) to determine the most economically efficient of two policy alternatives: (1) containment and translocation of sea otters under Public Law 99-625 or (2) natural sea otter range expansion with no translocation.

In order to analyze sea otters impacts upon shellfisheries, management, and tourism, we first modeled sea otter expansion for Santa Barbara and Ventura counties including the Channel Islands. Based on historic expansion data and population characteristics, an estimation of high, median, and low bounds of future sea otter population growth was projected. Although we investigated several models (*see discussion* Appendix B), estimates were calculated using a spatially explicit, sex and age structured, deterministic, matrix simulation model developed by Tinker *et al* (unpublished). Population expansion estimates were used to predict the impacts associated with sea otters.

The sea otter has a voracious appetite with consumption rates of 25–30% of its body weight each day (Costa, 1978,). Their diet consists primarily of macroinvertebrates, but prey preference is habitat dependent with dietary diversity increasing with increased time of occupancy (Wild and Ames, 1974; Kvitek and Oliver, 1987; VanBlaricom and Estes, 1997). Many of the sea otter's primary prey items (urchins, crabs, abalone, clams, and lobster) are commercially important to the Santa Barbara/Ventura area and contribute more than $11 million in annual revenues to local fishers (PacFIN, 2000). We estimated prey consumption distribution for the sea otter and projected impacts to fisheries (Appendix C). Sea urchins, crabs, and lobster are the primary fishery resources we consider in this analysis (Appendix D).

Tourism spending is the third largest source of revenue for the state of California and generates a total of $62.2 billion yearly (California Tourism, 2000, Ocean Agenda, 2000). The sea otter has a long established habitat in the Monterey Bay area, where viewing of the otter can generate significant associated revenues (Packard, Pers. comm.). We examined factors that influence tourism throughout the State categorized by county (Appendix E). Linear regressions were used to determine the magnitude of impact the otter has on tourism spending and revenues accrued thereof (Appendix F). These values are combined with sea otter population estimates for Santa Barbara/Ventura counties to project value-added benefits for the area over the next 25 years that will be attributable to the presence of sea otters.

The final step of our investigation was a cost-benefit analysis of the management scenarios mentioned above. We considered quantifiable costs to fisheries, costs for management, and gains to the local tourism industry. Costs and benefits were projected 25 years hence using the net present value with a discounted rate of 7 percent. In addition, we performed a sensitivity analysis using 5 and 9 percent discounted rates. While we recognize their importance, non-use and existence values were not used in this analysis.

In order to perform this analysis it is necessary to understand the impacted environments in greater detail. The following is an overview the impacted environments and the issues facing the management of the sea otter.

SECTION 2: IMPACTED ENVIRONMENTS

BIOLOGICAL ENVIRONMENT

The extirpation of the California sea otter from much of its range in the 1800's resulted in substantial changes in nearshore ecosystems (Estes and Palmisano, 1994). The sea otter is a predator of mollusks and urchins, which graze on stands of algae in coastal regions extending from California to the Aleutian Islands (VanBlaricom and Estes, 1986). As a consequence of the over-harvesting of sea otters, urchins became common and reduced the abundance and biomass of algal species (Estes, 1980; Duggins, 1981; VanBlaricom and Estes, 1987). Recovery of otter populations to their original densities will affect California nearshore ecosystem components: sea urchins, abalone, spiny lobster, clams, crabs, giant kelp, and finfish (McLean, 1962, Estes and Palmisano, 1974; Estes et al, 1978; Duggins, 1980; VanBlaricom and Estes, 1986; Siniff and Ralls, 1988).

The first report of impacts on the community level from otter foraging was in 1962. McLean (1962) observed sea urchin predation by otters, which was qualitatively coupled with released grazing on kelp within newly re-colonized historic habitat in central California. Subsequently, kelp forest abundance increased markedly and gave support to assemblages of finfish populations. This paradigm has since been supported by data gathered from several study sites along the eastern Pacific Coast by numerous researchers (Estes and Palmisano, 1974; Estes et al, 1978; Duggins, 1980;VanBlaricom and Estes, 1986; Siniff and Ralls, 1988). Although a general pattern has been suggested for the trophic interaction with the sea otter, several researchers prescribe caution when applying the paradigm locally in California. There are several studies that indicate kelp abundance along the California coasts oscillates in the absence of otters (Laur et al, 1982; Harold and Reed, 1985; Foster and Schiel, 1988). This relationship should not be discounted because there is a substantial fishery for kelp along the California coast. However, due to high uncertainties of the effects from sea otter-urchin-kelp interactions in Southern California, we do not include the potential benefits of kelp-sea otter dynamics in our analysis.

Until recently, the only major predator known for the sea otter was man, but recent accounts in Alaska indicate that killer whales and sharks are significantly preying upon sea otters (Estes, 2000). This could create a control of sea otters that would alter its impacts to the nearshore environment. Although these observations should be noted, there is a paucity of knowledge as to the effect on otters in the Santa Barbara area. Killer whales are sighted seasonally in local waters but predation on otters in the southern range is not documented. Therefore, we do not consider these dynamics in our analysis.

SOCIOECONOMIC ENVIRONMENT

Shellfisheries

Coinciding with sea otter expansion and manipulation of the food chain structure, several prey species of commercial importance are in decline. Although over-fishing may contribute, predation pressure from otters may have devastating effects for shellfish resources. As the sea otter population has increased in numbers, the frequency of conflict with shellfisheries has also increased. Many studies show that as the sea otter expands into new areas, macro invertebrate populations show dramatic population reduction (Ebert, 1968; Simenstad et al 1978; Hardy et al, 1982). Wild and Ames (1974) observed the disappearance of commercial and sport fisheries for abalone and rock crab in the path of otter. Estes and Duggins (1995) assessed the general paradigm in Alaska and found that two years after sea otter colonization the urchin size and biomass experienced a 100% decline. Simenstad et al (1978) suggested otters and large sea urchins could coexist if refuges exist for urchins such as substrate crevices or deep depths (>100m) beyond the otter's diving capabilities, but this would probably not support a viable fishery. Although the demand for shellfish is increasing, the total economic contribution to the Santa Barbara area is low (less 1 percent) in comparison to other industries such as tourism (USFWS, 1986a).

Tourism

Economic Importance

Tourism plays a very important role in the Californian economy. The tourism industry is the third largest employer in California after business services and healthcare and employs some 695,000 Californians. In 1999, tourism within California generated a total of $58.7 billion in destination spending and $4.5 billion in taxes, with $1.6 billion of that going to local governments. The tourism and travel industry grew an average of 5.2% annually since 1992 and provided an estimated 6% of California's Gross State Product in 1999 (California Tourism, 2000).

Santa Barbara and Ventura Counties both have thriving and significant tourism industries. 1998 tourism spending was $991 million and $808 million in Santa Barbara and Ventura Counties, respectively. Tourism in Santa Barbara County contributed 11 thousand jobs and raised $26 million in local taxes during 1998 (California Tourism, March 2000). This accounted for approximately 25% of local taxes and 6.5% of the workforce (Santa Barbara County, 2000). For Ventura County, tourism was responsible for 9000 jobs and $15 million in local taxes (California Tourism, March 2000).

Otters and Tourism

While the impact of sea otters on the ecosystem in which they exist is well documented, the impact they may have on tourism, if any, has not been previously estimated. There is evidence, however, that the presence of sea otters may have a positive impact on tourism in areas where they are present. Other marine mammals have substantial documented benefits. For example, in 1998 alone, $14 million were spent specifically on Californian whale watching tours (Hoyt, 2000). When indirect expenditures (food, accommodations, souvenirs, etc.) are figured in this amount rises to $64 million (Hoyt, 2000). It is obvious that sea otters are not directly equivalent to whales but there is evidence that sea otters, like whales, are a viewing attraction for tourists. Exit surveys at the Monterey Bay Aquarium, which attracted over 1.8 million visitors in 1999 (California Tourism, 2000), consistently ranked the sea otter exhibit as the most enjoyed exhibit in the aquarium and sea otter merchandise produced 22% of the gift and bookstore sales from January through September 2000 (Packard, pers. comm.).

SECTION 3: PROJECTION OF IMPACTS

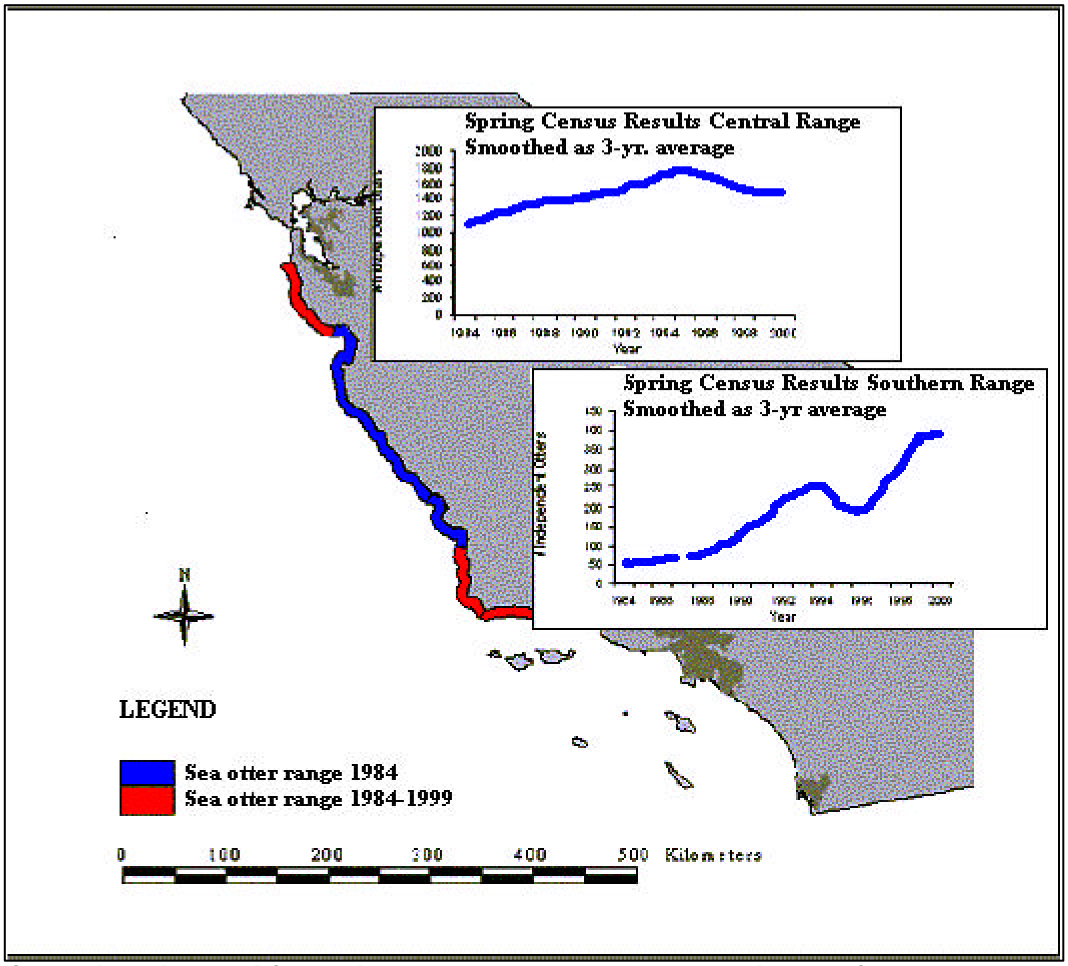
The following sections describe the analysis we performed for each of the components of the cost-benefit analysis. The first section presents how we modeled the expansion of the sea otter south of Point Conception over the next 25 years and discusses the results of that model. This is followed by an analysis of the fisheries and the possible losses that may occur due to the projected sea otter expansion. Tourism impacts are then modeled and the value-added benefit of sea otters to the tourist industry is calculated. Lastly, the costs of management through translocation and containment are presented.

POPULATION BIOLOGY, MOVEMENT, AND EXPANSION RATES

An adequate knowledge of the sea otter population dynamics is needed to understand and estimate range expansion and future population trends. These data are also important to evaluate the effects of otters on the nearshore environment, and within this study, the impacts to shellfisheries and local tourism. Data on population estimates and distribution, sex ratios and age groupings throughout the range, fluctuations in numbers, and range expansion were obtained from the U.S. Department of Fish and Wildlife (FWS), California Department of Fish and Game (CDFG), U.S. Geological Survey unpublished data, and assemblies of data that were collected for other purposes (*see References and Appendix A*).

The recovery of the sea otter from a small remnant population of approximately 50 individuals in the Big Sur area to the current population of 1877 independent otters (USGS, unpublished data) occurred with re-establishment of its former habitat range both north and south along the central California coast (Wild and Ames, 1974). Because of the incidence of young male wanderers far beyond the established range boundaries, delineating the established sea otter range and understanding the characteristics of range expansion is necessary in order to evaluate the ecological and socio-economic relationships of sea otters to the nearshore environment. Population census data aids in that understanding. In 1968, aerial counts of the sea otters began in coordination with observers on shore (Wild and Ames, 1974). Currently, population censuses are taken twice yearly (Appendix A -Table 9), but the USFWS acknowledge the technique is less than accurate and a 3 yr average is considered a more dependable indication of population trends (USFWS Biological Draft, 2000, Tinker et al, unpublished) (Figure 1).

Figure 1 – Southern sea otter range 1984 - 2000. Tinker, Estes, and Doak, unpublished.



A map of central-southern California showing sea otter range in 1984 and areas of range expansion over the period 1984-2000. Annual survey counts of independent otters (smoothed to 3 -year average) are shown plotted against time for the center portion of the range (Top) and the southern range periphery (Bottom).

Population model

Based on historical expansion data and population characteristics, an estimate can be made of future impacts by the sea otter to the nearshore environment and subsequent effects, spatially and temporally, to valuable resources. Frequently, the need to make forecasts about a population leads to the development of models. (For an overview of models considered and their estimates of population growth see Appendix B).

We investigated two models that have the greatest potential for estimating the sea otter expansion south of Point Conception: Fisher's diffusion with exponential growth, and the spatially explicit model of which Tinker *et al* permitted our modification and utilization. We chose to present the results from the spatially explicit model primarily because it was developed specifically for estimating changes in otter populations with and without translocation. Additionally, the input variables best resemble the actual dynamics of the population.

Spatially Explicit Population Model

Tinker *et al* (unpublished) developed a spatially explicit, sex and age structured, deterministic matrix model to estimate effects to the sea otter at the population level with and without translocation. 98.2% of 5000 simulations indicate that indirect impacts of the translocation would decrease the population. Trauma as well as competition for resources post capture and release, contributes significantly to population declines. Without translocation the model predicts there is still approximately a 5% decrease in the population over 20 years. We modified the model to examine population dynamics of the otter without translocation efforts for areas south of Point Conception. In addition we incorporated the Channel Islands into the estimation.

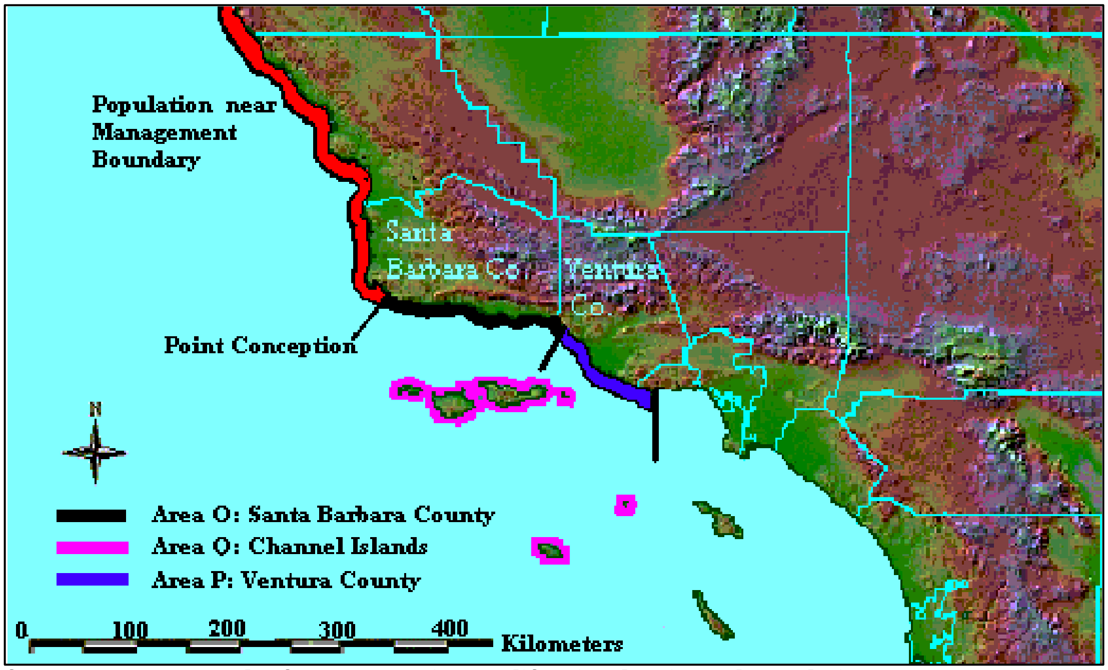
Methods

For estimation of movement of otters to and between areas, the southern range is divided into area blocks that are 125 km^2 with the exception of the islands, which is 720km^2. Although the user can vary the value, Tinker et al (unpublished) advise that these area boundaries are preferred because it is the maximum distance an otter is observed to move within a year. Areas of focus are: area O (125 km south of Point Conception), area P (125 to 250 km south of Point Conception), and area Q (the Channel Islands) (Figure 2). Population growth is estimated with two scenarios (1) low growth in the center of the population and high growth at the edges and (2) high growth in the center and low growth at the edges. In addition to the variables that influence population growth and movement presented in Appendix A, the following assumptions are made:

- The range width corresponds to the depth boundary at 5 fathoms (<2km)
- Starting population matches the Spring 2000 census (USGS, unpublished)
- Otter movement south of Point Conception divides evenly between the Channel Islands and the Santa Barbara/Ventura mainland with 45 otters initially in both areas
- The habitat is homogeneous; habitat dependence is not considered
- The distance around and within the Channel islands is assumed to be a continuous linear measurement of 720 km.

5000 simulations were run for each scenario.

Figure 2 - Map of the sea otter range south of Pt. Conception divided into sub-population areas.

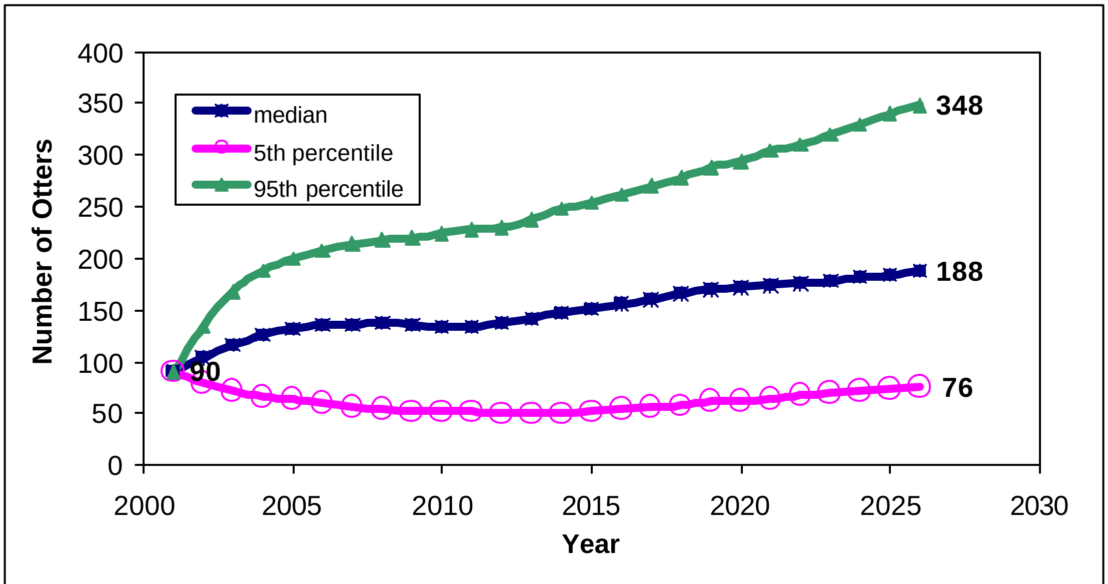


Map of sea otter range south of Pt. Conception, California, showing subpopulation areas M: Main population north of Pt. Conception; O: over Pt. Conception boundary to 125km south; area P: potential future range and Q: Channel Islands.

Results

Population estimates are integral in calculating temporal and spatial impacts to fisheries. The distribution of 5000 simulations for each area indicate that otter expansion in the next 25 years will be limited to areas O and Q; Santa Barbara county and the Channel Islands (Figure 3). Total populations are estimated at the 5th percentile, median, and 95th percentile with respective values of 76, 188, and 348 otters occupying the area after 25 years. This model predicts a yearly population growth of approximately 2% with a total population increase of 48% over 25 years for the Santa Barbara/ Ventura area.

Figure 3 - Estimate of otter population growth from a spatially explicit, deterministic simulation model.



Median and 95th percentile sea otter population estimates are presented from the distribution of high growth at the edges of the population. The 5th percentile is taken from the low growth simulations. These values encompass the upper and lower boundaries of the entire distribution of both scenarios.

Primarily rocky with abundant prey items, the Channel Islands are categorized as prime habitat for the sea otter with a carrying capacity of 2774 individuals (De Master et al, 1996). The Santa Barbara mainland is categorized as mixed and sandy bottom habitat, which is lower in quality (Preliminary Draft EIS, 1986, DeMaster et al, 1996). Habitat quality dictates the density and carrying capacity for an area. We may therefore underestimate the population for the islands and overestimate the population for the mainland. For further consideration, the actual population numbers may be higher for the Channel Islands in comparison to the mainland.

FISHERIES

Sea Otter Diet

To quantify the direct effects of returning otters on species of economic value we examined the caloric value of otter prey items and otter consumption rates.

Because of their small body size and lack of subcutaneous fat, the sea otter must consume large quantities of prey in order to obtain their energetic requirements. From a study performed on captive adults, Costa (1976) gives an average caloric demand of 253-calories/kg-body weight/day. This translates to consuming approximately 20-25% of an otter's body weight per day. With ocean temperatures in the range of 12ºC-20ºC, the sea otter's high metabolic rate allows them to maintain a core body temperature of 38.1ºC +/- .34ºC (USFWS draft EIS, 1986).

Otters have been observed to consume an array of benthic invertebrates with age class and individuals varying in their ability of successful capture of prey species (Siniff and Ralls, 1974). Estes et al (1981) suggest that the variables that affect successes are complex and may include the type of habitat and prey obtained, dive time, and foraging strategy. Generally, adult otters have more unsuccessful dives, but bring up less accessible, more energetically favorable prey like abalone. The diet consists primarily of macroinvertebrates, but preference is habitat dependent with dietary diversity increasing with increased time of occupancy (Wild and Ames, 1974; Kvitek and Oliver, 1987; VanBlaricom and Estes, 1997). Table 1 aggregates caloric data and fractional consumption per prey item from Costa (1978) and Ebert (1962) studies.

Table 1 - Prey Item Characteristics

Species	Length (mm)	Edible weight (g)	Caloric content (kcal)	Combustion (kcal/g)	Frequency (%)	Consumption (kcal/day)	# Of Inds	Energy supplied (%)
Abalone	120	148	145	0.983	10	1725	12	26
Rock Crab	109	275	182	0.662	9	1978	11	29
Kelp Crab	56	67	43	0.641	49	2525	59	37
Red sea urchin	40	10	6.5	0.623	14*	125	19	2
Purple sea urchin	30	4	1.6	0.402				
Turbin snails	19	3	3.6	1.091	15.4	392	108	6

Mean length, weight, and calorific content of the prey items available to sea otters foraging in the Pt. Cabrillo kelp forest. Taken from Costa (1978). Compares the relative energy contribution of the prey to the prey contribution. * Frequency for both species

We incorporated prey partitioning and consumption with fisheries data and population estimates to determine the rate at which competition with sea otters will precipitate the decline of harvestable shellfish. Size of prey items was approximated by modal sizes within the study site. Edible mass was considered the portion eaten by the sea otter: everything but the shell for mollusks, the gonads and digestive tract for urchins, everything but the dorsal carapace for rock crabs and the whole animal was consumed for kelp crabs (Costa 1978).

Fisheries Economic Analysis

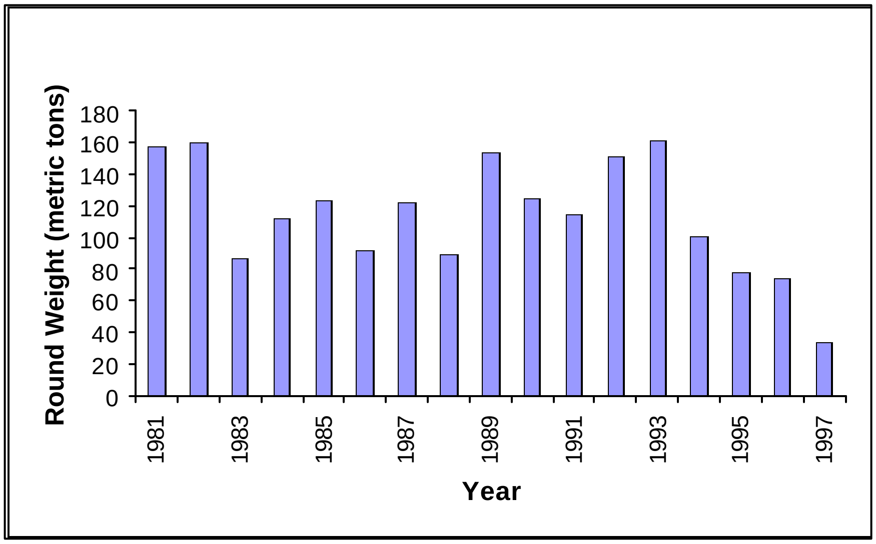
Fishing in California has a long history (Appendix D-F1) and sea otters re-colonizing the waters of Santa Barbara and Ventura Counties and the Channel Islands will potentially impact several modern fisheries. In order to determine economic loss, we must first establish the magnitude of profit for regional shellfisheries. Our study indicates that there is no profit in shellfisheries in the Santa Barbara region because the fisheries are effectively open-access. Profits are not equivalent to revenues generated from an activity, but are instead the revenue that remains when all costs are subtracted; costs include labor costs that are paid to crewmembers and vessel operators. In an open-access fishery, there is no limit on catch so participants will treat the fishery as a common property and fish to the point where their total costs are equivalent to their total revenues. This means that all rents (profits) are pushed to zero for the fishery as a whole (Please see Appendix D-F3 for a review of open-access fisheries economics).

The following is an overview of the fisheries that may be impacted by the otter.

Abalone

Prior to its closing, the abalone fishery was popular as a commercial and recreational fishery (Starr et al., 1998). The abalone fishery of Southern California provided substantial revenue for the region. Harvest in the Santa Barbara area peaked in 1993 at more than 161 metric tons with net present value of nearly 3 million dollars (PacFIN, 2000; U.S. Department of Labor, 2001). The annual catch fluctuated greatly (Figure 4) from 1981 until overfishing of this resource led to a complete closure of the fishery in 1997 (Starr et al., 1998).

Figure 4 - Abalone Landings for Santa Barbara County, Ventura County, and the Channel Islands (PacFIN, 2000).

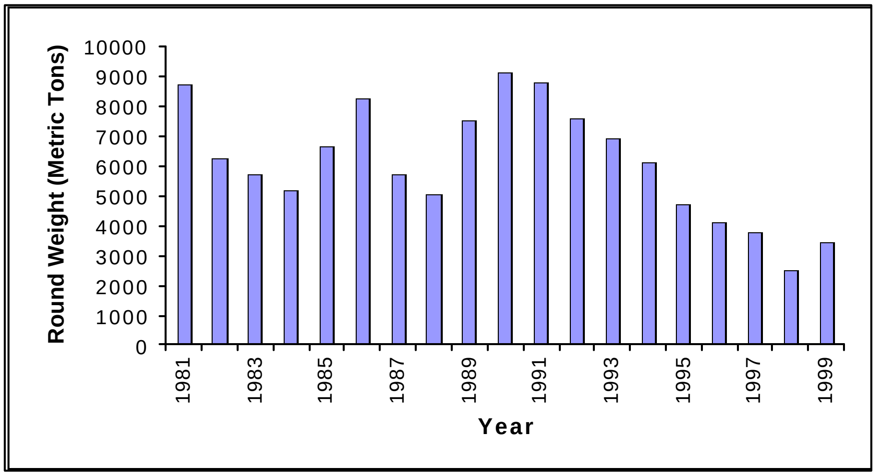


In the mid 1960s, sea otter presence in the Monterey area interfered with the commercial and recreational harvest of abalone (McEvoy, 1986). In addition to extensive overfishing, disease and environmental variability contributed to closure of the fishery. It is currently illegal to take, possess, or land abalone for commercial purposes from Southern California waters (CDFG, 2001). Because of the uncertainty regarding recovery of abalone populations to commercially viable populations we cannot calculate lost profit for this fishery. It is reasonable to assume that, should sea otters re-colonize the Channel Islands and the coastline of Southern California, the abalone populations may not reach a large enough number to be commercially viable. Abalone farming is a potential source of abalone for the future (Silva, 1982).

Sea Urchins

Sea urchin was considered a pest until the early 1970s because it grazed on kelp (Richards et al, 1997). Divers crushed sea urchins or used quicklime to kill them. (Rudie and Halmay, 1992). In 1971, in conjunction with the National Marine Fisheries Service, a small commercial fishery began in Southern California for the "underutilized" sea urchin for export to Japan (Haaker, 1992). In the Santa Barbara region, sea urchin harvests have fluctuated greatly since the 1980s, peaking in 1990, but declining steadily since (Figure 5).

Figure 5 - Sea Urchin Landings for Santa Barbara County, Ventura County, and the Channel Islands (PacFIN, 2000).



Management of the sea urchin fishery is accomplished through limited entry and fishery closure. The California Department of Fish and Game limits the numbers of permits issued in each year based on two calculations: (1) if the number of permits issued to prior permittees is less than 300 than new permits will be issued up to 300 and (2) if the number of permits issued to prior permittees is greater than 300, "the total number of new sea urchin diving permits available for issuance shall be one-tenth the difference between the total number of sea urchin diving permits issued prior to August 1 of the current permit year and the number of sea urchin permits issued during the immedia tely preceding permit year." (CDFG, 2001)

Regulations are such that new entrants are effectively barred from entering the fishery and fishers already invested in the industry maintain the right to fish. Although there are size restrictions and days that are closed to fishing, there is no catch limit or quota system (CDFG, 2001; please see Appendix D - F2 for selected California Commercial Fishing Regulations). Despite the fact that the number of participants in the fishery is limited, they are allowed to catch as much sea urchin as they can. The result is that the sea urchin fishery is in effect an open-access fishery and, as such, all rents are dissipated. Therefore, in terms of pure economic efficiency, the loss of this fishery results in no net loss to the economy (Gordon, 1954; Conrad and Clark, 1987; Munro, 1981; Hartwick and Olewiler, 1986).

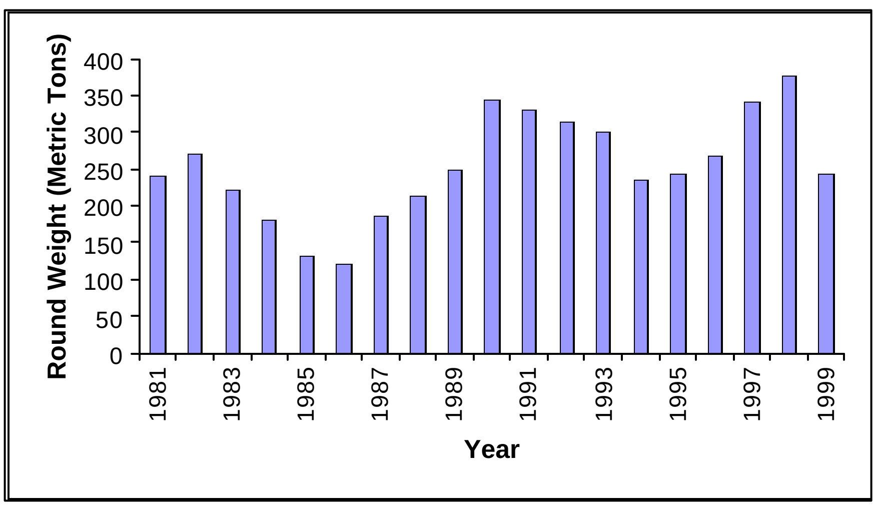
Licensing information provided by the California Fisheries Information System (2001) supports the argument that this is an open-access fishery. In 1999, 328 fishermen made landings in

Southern California (San Luis Obispo County and south) of 430 statewide permittees. Harvest ranged from 30 pounds landed to 137,880 pounds landed. 146 fishermen accounted for 80% of the catch. Of the 430 permitted urchin fishermen statewide only 409 made landings in 1999 (CFIS, 2001). This information suggests that opportunity exists for individuals to exert more effort in the fishery to increase their individual revenue. The fact that more individuals with permits do not catch more implies that added effort in the fishery as a whole does not result in added profit to individuals participating in the industry. As such, rents are dissipated and there is no net profit in this fishery.

Crab

Spider and Rock Crab are the primary species of crab fished in the Santa Barbara region (CDFG, 2001). Combined, these fisheries accounted for approximately 1 million dollars in 1998, its most productive year (PacFIN, 2000). Annual crab catch in the Santa Barbara region has fluctuated from year to year with some regularity suggesting that natural variations may be more of a cause of population size than current fishing effort (Figure 6).

Figure 6 - Crab Landings for Santa Barbara County, Ventura County, and the Channel Islands (PacFIN, 2000).

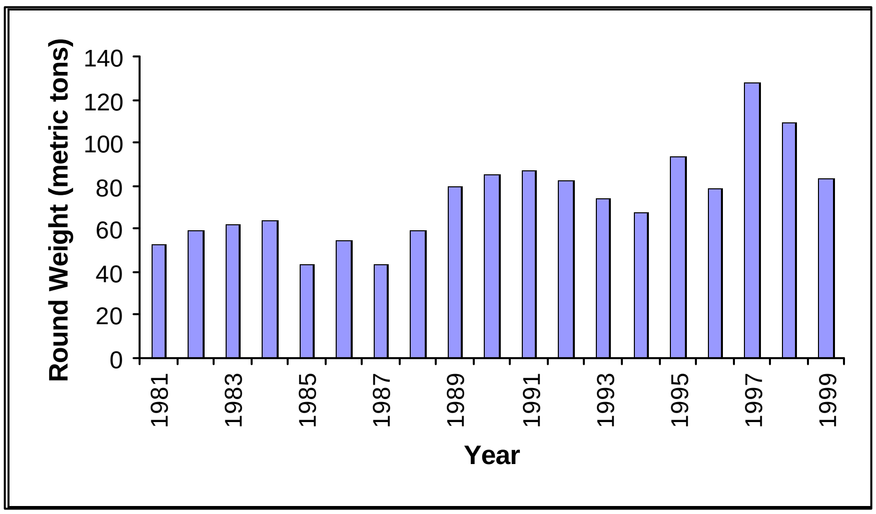


Harvest of Dungeness crabs is prohibited south of Point Conception. All remaining crab species in our study area are regulated through issuance of a Commercial Fishing License and a Trap permit. There are size restrictions and trap restrictions; however, there is no limit on the amount of crab that may be caught or the number of participants in the fishery (CDFG, 2001). The crab fishery in the Southern California Bight is therefore open-access and all rents are dissipated. In terms of pure economic efficiency, the loss of this fishery results in no net loss to the economy.

Lobster

Fishing for spiny lobster takes place south of the current range of the sea otter so potential impacts on the fishery are unknown. Annual catch peaked in 1997 at 128 metric tons with a net present value of nearly 2.5 million dollars (PacFIN, 2000; U.S. Department of Labor, 2001). Like crab, annual lobster catch in the Santa Barbara region has fluctuated from year to year with some regularity, suggesting that natural variations may be more of a cause of population size than current fishing effort (Figure 7).

Figure 7 - Lobster Landings for Santa Barbara County, Ventura County, and the Channel Islands (PacFIN, 2000).



Harvest of spiny lobster requires a Lobster permit in addition to a Commercial Fishing License. There are provisions in the regulations that dictate trap specifications; also, the lobster season is closed for part of the year and the entry of new participants is limited.

There were 424 Lobster Operator Permits issued in 1995, then limited entry was established in 1996 attempting to cap lobster fishers at 225. From 1996 to 2000 the number of lobster fishers has declined to 251 (CFIS, 2001). Despite the attempt to limit effort in this fishery through limited entry, the number of fishers has not declined below the goal of 225 per year. This is mainly due to a provision in the licensing guidelines that allows additional permits to be issued even if the number of permits issued to fishers from the previous year is in excess of 225.

> If the number of lobster operator permits issued [to participants from the previous year] is more than 225, the number of new lobster operator permits available for issuance shall be one-tenth the difference between the total number of lobster permits issued prior to July 1 of the current license year and the total number of lobster operator permits issued in the immediately preceding license year. If the number of lobster operator permits issued [to participants from the previous year] is less than 225, the number of new lobster operator permits available for issuance shall be the difference between the number of lobster operator permits issued and 225 (CDFG, 2001).

This caveat has a very important implication: it allows for new entrants despite the appearance of limiting entry. The fishers that have remained in the fishery have done so because they are generating enough revenue to cover their costs including paying themselves an income. New entrants are able to come into the fishery (albeit in a limited manner) and will do so if they see that opportunity exists to generate sufficient revenue to pay their costs including their income. Even if there have been very few new entrants, the fact that there are fishers remaining in the fishery despite the permit limit suggests that all these fishers are able to cover their costs, including paying their own salary. There is no catch limit or quota system, so the fishers are allowed to catch as much lobster as they can. The result is that the lobster fishery is in effect an open-access fishery, and, as such, all rents are dissipated. Therefore, the loss of this fishery results in no net economic loss.

Also, referring back to Figure 7 we see that annual harvest initially increased after the initiation of limited entry, but has fluctuated greatly despite decreased participants in the fishery. This indicates that variations in the stock of spiny lobster have more of an affect on annual harvest than effort. Fishers still exert maximum effort and their harvest is a reflection of fluctuations in lobster abundance. Without limits on harvest, fishers will attempt to harvest as much as possible despite fluctuations in lobster stock. As such, rents are dissipated and there is no net profit in this fishery.

Possible Income Losses

The assertion that these fisheries are open-access and as such have no value is not completely accurate. From past studies of other Pacific coast fisheries, Noetzel (1977) and Rettig and

McCarl (1985) indicate that income generated in Southern California fisheries is 50% of total revenue (as cited in USFWS Draft EIS, 1986). This is consistent with estimates of income that were developed from conversations with two local sea urchin fishermen (Halmay, pers. comm. and Steele, pers. comm.). This income may be transferred to other regions if the fishers move, or they may be transferred to another industry within the local economy. In a full employment economy this income will only be lost from Santa Barbara and Ventura Counties if the fishers move to another county. In our cost-benefit analysis we use zero for our estimate of lost fisheries profits due to sea otters; however, we use the 50% of gross revenue estimate to calculate the potential lost income to the local economy as a form of sensitivity analysis. We do recognize that income generated from other industries is not necessarily equivalent to the income generated from fisheries, but include the calculations as a measure of the robustness of the overall net benefit of sea otter recolonization.

Appendix D-F2 summarizes the methods we used to estimate the revenue losses and income losses to the lobster, crab, and sea urchin fisheries. The results of our calculations are summarized in Table 2.

Table 2 - Net Present Value of Total Changes in All Fisheries Incomes Over 25 Years (2001-2025) for three otter population projections.

	5th Percentile	Median	95th percentile
5% Discount Rate	$9,390,581.17	($15,053,944.73)	($20,478,885.81)
7% Discount Rate	$7,667,250.10	($12,086,008.85)	($16,834,241.00)
9% Discount rate	$6,373,074.91	($9,880,831.45)	($14,093,068.87)

Note that otter population estimates at the 5th percentile predict a decrease in sea otters, so there is actually a benefit to the fisheries.

TOURISM

As previously discussed the presence of sea otters may have significant impacts upon tourism. However, the sea otter is a non-market commodity and, without a direct market to give clues to the sea otter's impact upon tourism, it is difficult for policy makers to make adequate comparisons between benefits and costs. Therefore it is important to gain an understanding and a quantification of these effects. One solution to this quandary is the hedonic price method. In the following section, we discuss the use of the hedonic price method for measuring the impact of sea otters on tourism.

Methods

Hedonics

The hedonic price method is based upon the idea that a good or a service is valued based upon a combination of its characteristics or qualities (Winpenny, 1991). For example, a consumer is willing to pay a certain price for an automobile based upon the car's appearance, how many seats it has, its gas mileage, its safety rating, whether it is a 4-wheel drive, etc. The hedonic price method allows for a value determination of a good's specific characteristics, such as the value of an automobile's safety rating. Or, as in this report, the value of sea otters to the tourism industry.

The hedonic price method determines value through the use of multiple regression analysis (Winpenny, 1991). The basic model is:

$$Y = A + \alpha X_1 + \beta X_2 + \eta X_3 \ldots + \lambda P + \varepsilon$$

where Y is the dependent variable, A is a constant, the X's are various characteristic descriptors, and P is the characteristic being valued. For our analysis, Y is tourism, X represents individual factors that impact tourism (other than sea otters), and P is the population of sea otters. α, β, η, and λ are coefficients that define the marginal contribution of one more unit of each characteristic. Note that this model assumes linearity among variables.

Data

The hedonic price model requires a large, robust data set to achieve accurate results, especially for the complex relationship between otters and tourism. For the analysis to be meaningful and accurate, the regression must include as many of the major characteristics that impact tourism as possible. The absence of a key characteristic can be quite significant (Statsoft Inc., 2001). Thus, the hedonic price model presented in this report uses as many county characteristics pertinent to tourism as feasible. However, one characteristic that we were unable to locate data for was wildlife viewing (other than sea otters). While a number of variables exist (seal and sea lion populations, shore bird populations, number of whales sighted, etc), we found no research or data that is organized by, or is easily converted to, a county-based framework. Without this characteristic in our regressions, sea otter populations may proxy for other types of wildlife viewing. However, as changes in otter populations are unlikely to be correlated with changes in other wildlife viewing opportunities, this most likely did not influence our results.

Because Santa Barbara and Ventura Counties are the focus of this report, all data are organized at the county level. The model incorporates data for all 58 counties within the State of California. Where possible, time series data are used for years 1992 to 1998. We look at a number of different dependent variables including destination spending, tourism employment, tax receipts, each of which is broken down into subcategories. Sea otter population is an independent variable. A detailed description of all variables used in this model can be found in Appendix E. All values for these variables are in November 2000 dollars.

While the data set includes a variable for large tourist attractions within a county, we determined that four counties (Los Angeles, Orange, San Diego, and San Francisco) are, in and of themselves, national and international tourist attractions. Therefore, for these counties, we include a dummy variable in the regression as a control for their unique tourism characteristics. We also include dummy variables in the regression for all but one year to ensure that otter population does not proxy for variance in economic growth from 1992 to 1998.

Statistical Software

To perform the multiple regression analysis for this report, we used the statistical software S-PLUS 2000 (Copyright © 1988-1999 Mathsoft, Inc.). For information on the capabilities and limitations of this software, please see the Mathsoft website at http://www.insightful.com/.

Results of the Regression Analysis

This section discusses both the regression results and the calculations we performed in order to assess the total value-added benefits to tourism due to sea otter expansion. This section describes the results of the regression analysis and the sea otter's predicted impacts upon the tourism industry of a county. We discuss only the statistically significant results (p-value < 0.05). Appendix F contains a summary of all the regression results.

In order to gain a general understanding of the significance each variable contributes to the overall model, we executed multiple simple regressions on the data set. The largest factor affecting tourism within a county was that county's population. Population, alone, explained 82% of the destination expenditures among counties. Including the other variables explained an additional 13% (R-squared ~0.95 for most regressions).

We theorized that there was a diminishing return to tourism associated with sea otter populations. The presence of sea otters may add value to the tourist industry of an area but the magnitude of the value-added may differ between the first otter and the thousandth otter. We used a quadratic component of sea otter populations in the regression to test the non-linearity hypothesis, however the coefficient on the quadratic term was statistically insignificant.

As destination spending is the total of all travel related expenditures in a county including all local and state taxes paid directly by travelers (excluding income or corporate taxes), we used it to calculate benefits for the CBA. Table 3 summarizes the partial regression of otter population on the various destination spending variables. The coefficient describes the median dollar amount spent by tourists due to the presence of one additional sea otter. The 95%-confidence interval spans the statistically plausible range of values, which provide estimated upper and lower bounds for the predicted impact.

Table 3 – Partial regression results of otter population on destination spending.

Dependent Variable	Otter Pop. Coefficient (millions of $)	Standard Error	95% Confidence	t-value	p-value	R^2
Accommodation Spending	0.1499	0.0216	0.0423	6.9225	0.0000	0.9420
Eating-Drinking Spending	0.0749	0.0197	0.0386	3.8031	0.0002	0.9499
Recreation Spending	0.0386	0.0121	0.0237	3.1884	0.0015	0.9691
Retail Spending	0.0694	0.0288	0.0564	2.4091	0.0165	0.9558
Total Destination Spending	0.3796	0.1069	0.2095	3.5502	0.0004	0.9584

As shown above, the impact of each sea otter on total destination spending within a county is equivalent to $379,600 +/- $209,500 per year. The largest impact on tourism spending is found within the accommodation sector followed by eating-drinking, retail, and recreation spending.

When analyzing the sea otter's effect upon a county's economy, overall expenditures are not an accurate measure of benefits. Many costs involved in those expenditures take the form of used resources (i.e. materials, salaries, etc.) and, without the presence of tourism, many of these resources would be utilized elsewhere in the economy. An increase in use of these resources due to sea otters can only be considered a transfer from one industry to another and not an increase in value-added benefits. However, there is a portion of destination spending that would not exist without tourism, particularly net profits, tax receipts (excluding income tax), and payments to fixed factors such as land. Together, these are the value-added portions of tourism expenditures. As pure profit derived from land rentals is difficult to isolate, we proxy land rents using the lease and rental payments on property, noting that this overestimates true economic rent as some lease payments cover maintenance costs, which are transferable to other industries.

To determine the value-added portion of tourism spending due to sea otters, we converted the expenditure coefficients into their value-added components. To accomplish this, we calculated the percentage of sales or revenue that was value-added for each of the four statistically significant expenditure variables using the US Census Bureau's report 1997 Business Expenses (2000). Table 4 lists the percentage value-added of each variable and the converted dollar values for each of those variables.

		VALUE-ADDED (MILLIONS OF $)	
Subcategory	**Value-Added Conversion Factor**	**Median Converted Otter Coefficient**	**95%-Confidence**
Accommodation Spending	7.8%	0.0117	0.0033
Eating-Drinking Spending	49.1%	0.0368	0.0190
Recreation Spending	2.7%	0.0010	0.0006
Retail Spending	29.1%	0.0202	0.0164
Total Value-Added		0.0697	0.0393

Table 4 - Yearly value-added destination spending per otter.

Ideally, for the sum of the subcategory coefficients to be used as total value-added, the coefficients should be estimated using simultaneous equations (McAusland, pers. comm.). This is problematic in that each of the simultaneous equations requires different independent variables in order to avoid multi-colinearity. This type of analysis is beyond the scope of this report. As the subcategories are necessary to convert to value-added benefits and the sum of the coefficients in our regressions are almost equivalent to the total destination-spending coefficient, we use the sum of the subcategory coefficients as a proxy for the total value-added benefits.

Before this conversion of the destination spending coefficients to their value-added components, accommodation spending showed the largest impact, with over $149,000 per sea otter per year. However, after the conversion to its value-added component, accommodation spending provides only $11,700 per otter per year, dropping it to the third most important sector. The eating-drinking and retail sectors provide the largest benefits after value-added conversion.

In addition to benefits realized through tourism expenditures, sea otter expansion influences increased value to both employment and tax receipts within a county. The majority of predicted jobs are within the accommodation and eating-drinking sectors. The median predicted employment value of an individual sea otter is approximately 2.8 +/-2.6 total jobs (Table 5). The wide range of values predicted by the 95%-confidence interval makes projection of jobs gained due to sea otter expansion difficult.

Table 5 - Partial regression of otter populations on employment.

	Otter Pop. Coefficient (#of jobs)	Standard Error	95% Confidence	t-value	p-value	R^2
Accommodation Employ.	1.6618	0.3205	0.6282	5.1846	0.0000	0.9495
Eating-Drinking Employ.	1.5293	0.4489	0.8798	3.4065	0.0007	0.9351
Retail - Employment	0.3797	0.1971	0.3863	1.9266	0.0000	0.9323
Total Employment	2.7833	1.3322	2.6111	2.0892	0.0374	0.9617

While the destination-spending variable includes many components of state and local taxes (transient, gas, and local sales taxes), it is still useful to isolate the benefits to tax receipts that arise from sea otter expansion. This is especially true of local tourism taxes, which are an important proxy for value-added revenue to the local governments. Local taxes from tourism will generate $19,400 +/-$6,500 per otter per year (Table 6).

Table 6 - Partial regression of otter populations on taxes.

	Otter Pop. Coefficient (millions of $)	Standard Error	95% Confidence	t-value	p-value	R^2
Local Taxes	0.0194	0.0033	0.0065	5.9537	0.0000	0.9598
State Taxes	0.0127	0.0054	0.0106	2.3464	0.0195	0.9575
Total Taxes	0.0321	0.0083	0.0163	3.8556	0.0001	0.9612

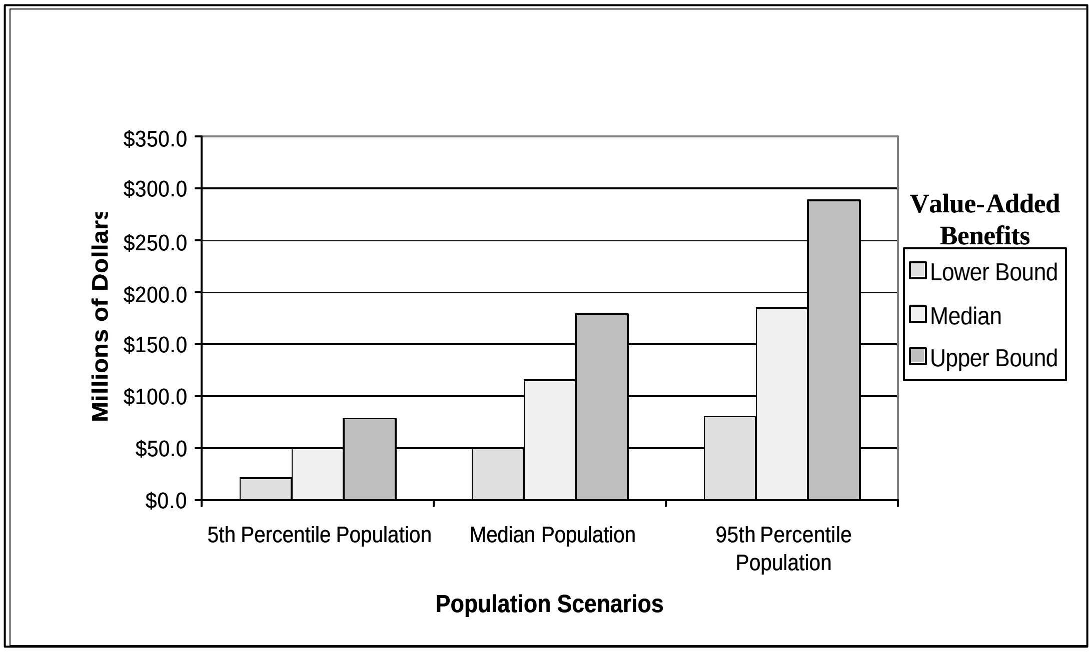
Impacts – 25 Year Timeframe

Combining the results of the sea otter population model discussed previously with the above tourism benefits, we calculated the total value-added to Santa Barbara and Ventura Counties over a 25-year timeframe in the absence of sea otter removal. We then discounted these values with a rate of seven percent per year and performed a sensitivity analysis with a five and nine percent rate as suggested by the U.S. Office of Management and Budget (2001).

It is important to note here that the inclusion of the Channel Islands into this analysis presents an interesting issue. As both Santa Barbara and Ventura Counties have a Channel Island tourist industry, the tourism benefits gained from an increased sea otter population in the Channel Islands are split amongst Santa Barbara and Ventura Counties. However, the actual partitioning of benefits is unknown. This does not present a problem for this analysis however, as the benefits to Santa Barbara and Ventura Counties are simply aggregated to get a total value.

The value-added due to the predicted sea otter expansion over the next 25 years is substantial. Combining the lowest tourism benefit with the lowest sea otter growth and the highest discount rate, the total discounted value-added still equals over $18 million in 25 years. The median value-added (tourism benefits and otter growth), at the OMB suggested discount rate of seven percent, is over $114 million. Figure 8 summarizes the medium predicted tourism benefits for the median, 5th and 95th percentile sea otter growth scenarios.

Figure 8 - Sea Otter Benefits to Tourism (7% Discount Rate)



MANAGEMENT

Otter Containment

If the Translocation Program were declared a failure, then containment of the otters would no longer be necessary. However, under the 6th section of understanding between the USFWS and CDFG for the translocation program states:

> If, after consultation with CDFG and the Marine Mammal Commission (MMC), the translocation program is declared a failure, based on the criteria defined in the federal rulemaking (experimental population of Southern sea otters), the USFWS shall, subject to provisions of the Administrative Procedures Act and other requirements of federal law, amend that rulemaking to terminate the program, and the USFWS shall also capture and place back into the range of the existing (mainland) population, all sea otters remaining within the translocation and management zones. The CDFG agrees to cooperate and assist in such removal efforts to the maximum extent feasible. Following the aforementioned action, all containment efforts in the management zone shall cease.

In order for the USFWS to remove all otters that venture into the management zone, there are numerous associated containment costs with the following assumptions:

- Each otter removed would be relocated to an area on the northern end of the southern range

- Otters would be monitored with tags
- Estimated number of otters in Southern California in 1998 was 121
- Capture areas would be primarily Coho Anchorage, San Miguel Island, and San Nicolas Island
- The plan to remove the 121 otters that had ventured into the management zone was estimated to incorporate 1-3 years of bi-weekly field operations. This plan includes removing the San Nicolas population. The USFWS Ventura Office estimated the following annual budget (Greg Sanders, pers. comm.)

Total costs for removal of 121 otters would depend on the time the operation would require, but maximum of 3 years at $2,955Kwould entail $24K per otter compared to minimal costs of 1 year at $985K and $8K per otter in current dollars.

For the cost-benefit analysis, we will evaluate only the translocation/no translocation options. We estimate that with translocation, initial costs would include removing all otters south of Point Conception, and then annual costs thereafter include removing those otters that enter the management zone. Net present value of the management costs are calculated at a 7 percent discount rate over 25 years with a value of $1,041,000. In addition, a sensitivity analysis at 5 and 9 percent produced $674,000 and $860,000, respectively. For an outline of specific management costs, see Appendix H.

We assume that once the current population south of Point Conception is removed, the rate of expansion for the otters will follow the previously modeled growth estimates. It should be noted however that, although the otters removed would be placed in the northern area of their range, past efforts have shown that otters travel as far as 125 km in a year and frequently return to the point of capture (Benz, 1996, Siniff and Ralls, 1988). Therefore, the rate the otters return to the area south of Point Conception might be higher than our estimates.

SECTION 4: COST-BENEFIT ANALYSIS RESULTS

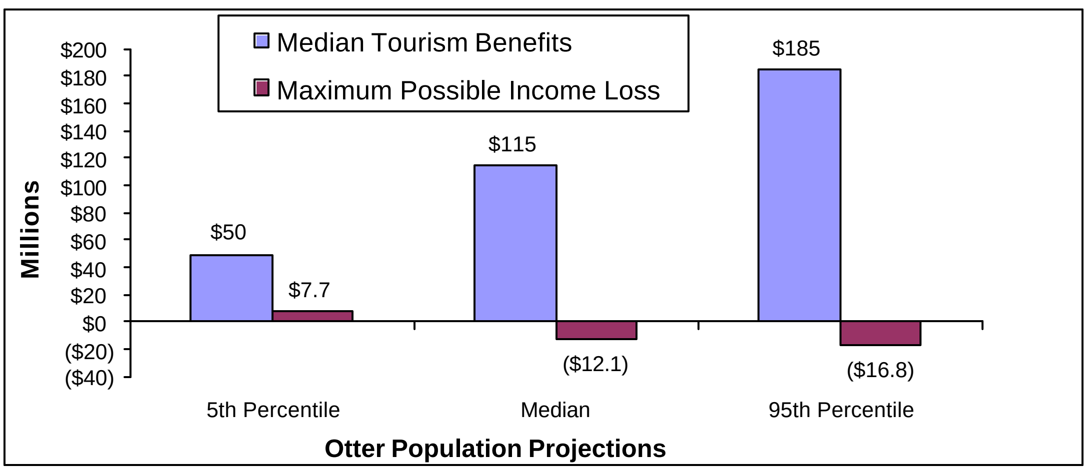
We compared enforced translocation under Public Law 99-625 with the current status of no translocation and natural range expansion. Table 7 shows the net cost estimates for enforcing translocation under P.L. 99-625. It is clearly evident that the no translocation scenario is the economically efficient policy option.

Table 7 - Net Costs of Enforced Translocation Under P. L. 99-625 for Three Otter Population Projections (7% discount rate)

	5th Percentile	Median	95th Percentile
Management Costs	-$742,000	-$1,042,000	-$1,525,000
Tourism Losses	-$49,600,000	-$114,800,000	-$185,100,000
Total Costs	*-$50,342,000*	*-$115,842,000*	*-$186,625,000*

Utilizing a 50 percent profit margin for fisheries as a sensitivity analysis, the total cumulative effect of possible losses is still outweighed by the total benefits of tourism associated with the sea otters presence (Figure 9).

Figure 9 – Comparison of median predicted tourism benefits to maximum possible income losses in Santa Barbara and Ventura Counties (7% discount rate).



Our results suggest that allowing the otters to expand their range naturally throughout Southern California will yield greater economic benefit to the economies of Santa Barbara and Ventura Counties than will implementing zonal management to protect fisheries.

SECTION 5: FUTURE CONSIDERATIONS

COST-BENEFIT ANALYSIS AS A TOOL FOR DECISION-MAKING

Decision makers are faced with the awkward problem of evaluating potential outcomes and choosing policies to achieve these outcomes in the presence of intense complexity. The sea otter conflict is a prime example where well-intended decisions lead to unexpected outcomes. Therefore it is important that the process for decisions regarding the management of the otter have a framework for structuring information that addresses complexity in a tractable manner. Cost-Benefit Analysis is an analytical tool, which has the potential to significantly promote this process. It provides a means for systematically comparing the value of outcomes with the value of resources achieving the outcomes required. When all else is equal, the more efficient scenario should be chosen over the less efficient one.

Cost-benefit analysis is capable of providing special weighting for certain issues of equity, such as the imbalance of impacts to either the sea otter or to harvesters of the resources impacted by otter range expansion. CBA cannot, however, measure the multi-dimensional aspects of overall policy desirability that may include such factors as sustainability, altruism, ethics, public participation in the decision process, and other existence and social values. The intent rather, is to provide the magnitude of the differences between gains and losses. The most economically efficient choice may not be optimal without weighing efficiency against other important criteria that would affect overall social desirability. Therefore this cost-benefit analysis may inform the decision process, but it cannot by itself determine policy. Any decision made using this analysis should take this into account.

The following sections describe several considerations that may reduce uncertainty and make future estimates of impacts more precise. For clarity, they are broken down into separate topics.

NON-USE VALUE

While tourism and fisheries revenues provide a way to measure "value" to society, there are a number of other ways which, although much more difficult to measure, are important in determining value to society. These things, known collectively as non-use values, are values that a person places on a good even though that person may never use that good (Kolstad, 2000). In the case of the sea otters, some people may place a value simply upon knowing that the sea otters will continue to exist, whether or not they will ever actually see a sea otter. Or they may value the sea otter's importance to an ecosystem as a keystone species and, subsequently, to the health of that ecosystem, even if they never gain any direct benefit from that ecosystem. These values need not be positive. Some people may place value on the reduction in the sea otter population in order to expand business interests, for example. This non-use valuation of the sea otter (a negative value) is just as important to determining the overall value of the sea otter. Society may also place a value simply upon knowing that fishing communities and fishermen continue to exist.

Fishermen also place intrinsic value on their occupation. Gordon (1954) asserts that due to a number of factors, fishermen will actually work for less than the going wage. The difference between the going wage and the wage earned by fishermen represents an intrinsic value of fishing. The loss of these fisheries, even if there is no net economic loss to society, will still have a profound effect on the participants. Fishers are generally a community of people who have dedicated themselves to a lifestyle, not just a profession (Halmey, pers. comm.). For these individuals, their chosen profession reflects a desire to earn a living from the sea. Losing their job will not only affect their pocketbook, but also their social community (Halmey, pers. comm.).

While the inclusion of non-use values was outside the scope of this project, we acknowledge the importance of taking these values into account when making policy decisions. Therefore, we recommend that the non-use values pertaining to the sea otter-shellfishery conflict be researched and analyzed for use in the policy making process.

MODELING

In order to effectively predict prey reduction by the invasion of otters into areas already occupied by urchins, abalone, crabs, clams and lobster, densities of their prey must be ascertained. For a more precise estimate of the expansion of the southern sea otter, a predator-prey model combining reaction-diffusion might be utilized. This would allow movement to be combined with population dynamics and multi-species interaction in addition to predator-prey interactions of the Lotka-Volterra model (Holmes et al, 1994). At the present, there is a paucity of knowledge about the abundance, density, and population dynamics of these invertebrates along the California coast required for this model.

TOURISM

As mentioned earlier, the benefits to tourism presented in this report are based upon an assumption of linearity. It is possible, however, that the otter population must reach a threshold density before tourism benefits occur, since tourists may be unwilling to make a journey for viewing purposes unless an otter sighting is assured. The possibility of the existence of this threshold level deserves further research.

The Channel Islands present an interesting problem for the estimation of tourism benefits due to sea otters. As there are no areas similar to the Channel Islands within the present sea otter range, the predicted impacts from the Channel Islands population are more likely to vary from what will actually be realized in the future. Large population centers are absent from the Channel Islands and one cannot simply walk out to them and look for sea otters. The Channel Islands population of sea otters may be more or less "valuable" to tourism than the mainland population. This analysis regards the population in the Channel Islands as if it is a mainland population but it is understood that this may produce systematic errors. We recommend that a more thorough analysis of the tourist industry of the Channel Islands be performed and analyzed for possible sea otter relationships.

In addition, performing a travel-cost analysis of the sea otter's impacts upon tourism would provide a valuable comparison to the linear regression results.

FISHERIES

In addition to modeling the predator-prey dynamics previously mentioned there are two factors that need to be taken into account in order to more effectively understand fisheries impacts. First, fisheries trends in absence of competition with sea otters need to be predicted. This would require a detailed bioeconomic model of the fisheries and would allow more precise calculations of future fisheries revenues. This model should also predict the rate at which fishers would leave the industry as harvest declines. Second, a better understanding of the costs incurred by fishers and the available profit in each fishery would allow a more accurate calculation of future profits.

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SECTION 7: APPENDICES

APPENDIX A - SEA OTTER BIOLOGY

Home range/Territory and Distribution

A population of roughly 2000 southern sea otters lives along the stretch of less than 400 km off the northern California coast around Monterey Bay (US Fish and Wildlife Service 1996; Estes, 1990) to Point Conception in the south. Research indicates the distribution of otters within their home range is limited by the type and amount of habitat available, carrying capacity of the habitat (K), and number of sea otters present and the behavioral characteristics of the population (Wild and Ames, 1994). The center of the otter's range is comprised primarily of females of all age groups, dependent pups and recently weaned juvenile males while juvenile males dominate the edges of the expanding population (Siniff and Ralls, 1988).

A translocated experimental population of roughly 12-16 independent otters is located at San Nicolas Island but this colony is below equilibrium density and continues to decline (Benz 1996, Bodkin et al. 1996, Estes et al. 1996). Populations of about 100 individuals are frequently observed south of Pt. Conception at Coho Bay.

Growth and Equilibrium

With exception of the mid-1970's to the early 1980's when set net fisheries impacted the sea otter population, the rate of otter population increase has consistently been estimated at 5% per year (Estes et al, 1996). This rate is low in comparison to the maximum rate observed for the Alaska otter population, which increased nearly 20% during early stages of recovery (Estes, 1990).

Estimates of the carrying capacity (K) for the southern sea otter in California were based on historical abundance estimates of 16,000-18,000 along the U.S. west coast (DeMaster et al, 1996, Ralls et al, 1983). Estimates of equilibrium densities taken from DeMaster et al (1996) in three different habitat types are: 13.21 otters per square nautical mile (nm^2; nm=1. 852km) for rocky habitat, 6.95 otters per nm^2 for mixed habitat, and 1.19 otters per nm^2 for sandy habitat (Table 8).

Table 8 - Summary of geographical areas in Santa Barbara/ Ventura counties from sea otters

From DeMaster et al (1996). Summary of geographical areas in California suitable for sea otters, where each area has been assigned a habitat type (and associated equilibrium density- D_i). The surface area (nm^2) for a particular geographical area was calculated, assuming a maximum feeding depth of 130 ft (40 m). The number of otters per area was calculated as the product of Di and area. * nm^2; 1 nm = 1.852 km

	Geographical Location South to North	Habitat	Area (nm^2) (km^2)	Number of Otters (K)	*Density of (Otters/nm^2)	Density of (Otters/km^2)
1	Mexican border - Pt. Loma	sandy	46 144	55	1.2	.36
8	Pt. Dune - Pt. Mugu	rocky	12 41	159	13.21	3.85
9	Pt. Mugu - Ventura	sandy	83 284	99	1.19	.36
10	Ventura - Pt. Conception	mixed	62 213	431	6.95	2
11	Pt. Conception - Rocky Pt.	mixed	19 65	132	6.95	2
38	Channel Islands	rocky	210 720	2774	13.21	3.85

It is thought that the otter cannot effectively forage in waters deeper than 130 ft (40m) (Ralls et al, 1995). Tinker *et al* (unpublished) estimated that this typically bounds the otter to within about 1 kilometer from shore along the coast. Utilizing the 1996 USFWS survey of 2400 animals, the equilibrium density was calculated based on the density of otters in sandy habitat of Monterey and Morro bays, mixed habitat between Año Nuevo and the Santa Maria River, and rocky habitat between Cayucos Point and Monterey Bay (Table 10). It should be noted that population numbers have declined since these estimations were performed.

Table 9 - Biannual sea otter census data 1982-2000

Year	Season	Total Pups	Independents	Total Otters
1982	Spring	222	1124	1346
	Fall	147	1204	1351
1983	Spring	121	1156	1277
	Fall	163	1060	1225
1984	Spring	123	1180	1303
	Fall	Data	----	----
1985	Spring	242	1119	1361
	Fall	150	1065	1215
1986	Spring	228	1358	1586
	Fall	113	1091	1204
1987	Spring	226	1435	1661
	Fall	110	1260	1370
1988	Spring	221	1504	1726
	Fall	Data	----	----
1989	Spring	285	1571	1856
	Fall	115	1492	1607
1990	Spring	214	1466	1680
	Fall	120	1516	1636
1991	Spring	241	1700	1941
	Fall	138	1523	1661
1992	Spring	291	1810	2101
	Fall	134	1581	1715
1993	Spring	217	2022	2239
	Fall	143	1662	1805
1994	Spring	283	2076	2359
	Fall	115	1730	1845
1995	Spring	282	2095	2377
	Fall	137	2053	2190
1996	Spring	315	1963	2278
	Fall	161	1858	2019
1997	Spring	310	1919	2229
	Fall	197	2008	2205
1998	Spring	159	1955	2114
	Fall	211	1726	1937
1999	Spring	232	1858	2090
	Fall	162	1808	1970
2000	Spring	264	2053	2317

Table 10 - Summary of geographic areas in California suitable for sea otters.

	Geographical Location	Habitat	Area (nm2)	Number of Otters (K)
1	Mexican border - Pt. Loma	sandy	46	55
2	Pt. Loma - Bird Rock	sandy	10	12
3	Bird Rock - Pt. La Jolla	rocky	7	92
4	Pt. La Jolla - Corona Del Mar	rocky	64	845
5	Corona Del Mar - Pt. Fermin	sandy	118	140
6	Pt. Fermin - Palo Verdes Pt.	mixed	6	42
7	Palo Verdes Pt. - Pt. Dune	mixed	80	556
8	Pt. Dune - Pt. Mugu	rocky	12	159
9	Pt. Mugu - Ventura	sandy	83	99
10	Ventura - Pt. Conception	mixed	62	431
11	Pt. Conception - Rocky Pt.	mixed	19	132
12	Rocky Pt. - N. Pt. Pedernales	mixed	8	56
13	N. Pt. Pedernales - Santa Ynez River	mixed	10	70
14	Santa Ynez River - Purissima Pt.	rocky	2	26
15	Purissima Pt. - Lions Head	sandy	35	42
16	Lions Head - Pt. Sal	mixed	16	111
17	Pt. Sal - Shell Beach	sandy	48	57
18	Shell Beach - Pt. San Luis	rocky	4	53
19	Pt. St. Luis - Hazard Canyon	rocky	22	291
20	Hazard Canyon - Cayucos Pt.	sandy	33	39
21	Cayucos Pt. - Monterey	rocky	117	1546
22	Monterey - Capitola	sandy	75	89
23	Capitola - Sand hill Bluff	mixed	7	49
24	Sandhill Bluff - Ano Nuevo Pt.	rocky	7	92
25	Ano Nuevo Pt. - Pt. San Pedro	mixed	93	646
26	Pt. San Pedro - Pt. Lobos	sandy	93	111
27	Pt. Lobos - Bodga Head	mixed	102	709
28	Bodega Head - Fort Bragg	rocky	97	1281
29	Fort Bragg - Cape Vizcaino	rocky	35	462
30	Cape Vizcaino - Pt. Delgado	mixed	54	375
31	Pt. Delgado - Punta Gorda	sandy	30	36
32	Punta Gorda - Cape Mendocino	mixed	23	160
33	Cape Menocino - Trinidad Head	sandy	124	148
34	Trinidad Head - Patricks Pt.	rocky	21	277
35	Patricks Pt. - Klamath River	sandy	63	75
36	Klamath River - Pt. St. George	rocky	71	938
37	Pt. St. George - Oregon Border	sandy	47	56
38	Channel Islands	rocky	210	2774

APPENDIX B - DISCUSSION OF MODELING POPULATION DYNAMICS

Exponential Growth

The spring census of 2000 observed 91 otters south of Point Conception with the southern most observation in the Summerland area. The simplest approach to projecting the otter population is to assume that population south of Point Conception will grow exponentially:

$$N(t) = N(0)*e^{-rt} \quad (1)$$

where N is population abundance and r is the intrinsic rate of growth. If the 91 individuals observed south of the Point in 2000 grow at the historic rate (r = 0.056), there will be 132 otters in Santa Barbara/Ventura Counties in 5 years, 172 otters in 10 years, and 390 individuals in 25 years. DeMaster et al (1996) estimate the carrying capacity for the area of Point Conception to Ventura ($62nm^2$, $213km^2$) to be 431 (Table 10). Assuming homogeneity of the mixed habitat, the K density would be 2 otters/km^2. If the initial conditions assume that all 91 otters are within 50 km south of Point Conception at time 0, then evenly split between the mainland and the islands, and if a km^2 area reaches carrying capacity before expansion into an adjacent area, the otter range in 25 years would be approximately 83 km south of Point Conception. For further consideration, if the population splits between the Channel Islands and the mainland, expansion and time to reach capacity would extend much farther into the future. For example, with the Malthusian growth model, dependent upon the initial population, it would take 41 years for the otters to reach carrying capacity within the area from Point Conception to Ventura County (Table 11):

$$t(\ln R) = \ln\left(\frac{Nt}{N(0)}\right) \quad (2)$$

Table 11 - Exponential growth model

Estimate of Otter Abundance (N) and Range Expansion (R) for Santa Barbara and Ventura Counties (~ 1471 km^2)**						Santa Barbara Co. Yrs to reach K (431) (213km^2)	Ventura Co. Yrs to reach K (689) (538 km^2)	Channel Islands Yrs to reach K (2774) (720 km^2)
5 yrs		10 yrs		25 yrs				
N	R (km)	N	R (km)	N	R (km)			
132	33	192	43	390	83	41	50	75

Estimation of abundance and distance traveled over time for the southern sea otter.
§ assumes an initial population of 45 individuals
***Assuming K (2otters/km^2) is reached before expansion into an adjacent area.**
****Assuming that the average width of the otter habitat is approximately 1 km**
*****Assuming that the expanding population splits evenly between the mainland and the Channel Islands from Pt Conception**

The results of this model indicate that the sea otter population for entire Santa Barbara/Ventura/Channel Islands in 25 years will be approximately 390 individuals. The area will reach carrying capacity in approximately 75 years.

Partial differential equation models

One of the major mathematical tools for analyzing spacial/temporal processes is the partial differential equation (PDE). With PDE's, modeling population dynamics can be enhanced by simultaneous addition of processes that occur spatially and temporally (Holmes et al, 1994).

In addition to the environmental conditions of the potential habitat that may present barriers, successful establishment of an invading species depends on the sex ratio, age structure, genetic diversity, breeding system, social structure of the population, and interactions with indigenous species (Shigesada and Kawasaki, 1997).

Diffusion model

Population growth with diffusion movement introduced by Fisher (1937) and Skellam (1951) were the first efforts of combining both concepts in a model (as cited by Lubina and Levin, 1988, Holmes et al, 1994). These models include habitat dependent and density dependent movements. In a 2-dimensional diffusion model, organisms are assumed to have a random walk at a rate that is consistent through space and time (Holmes et al, 1994):

$$\frac{\partial n(x,y,t,)}{\partial t} = D\left(\frac{\partial^2 n}{\partial x^2} + \frac{\partial^2 n}{\partial y^2}\right) \qquad (3)$$

where $n(x,y,t)$ is the density of species at a given coordinate position x, y, at time t, and $D\left(\frac{Distance^2}{time}\right)$ is the diffusion coefficient which measures the rate at which the population disperses from the origin (Holmes et al, 1994). The solution of the diffusion PDE is:

$$n(x,t) = \left(\frac{n_o}{4pDt}\right)\exp\left(-\frac{x^2+y^2}{4Dt}\right) \tag{4}$$

where n_0 is the initial population. This is a 2 dimensional Gaussian distribution with a mean squared displacement (MSD) of 4Dt (Holmes et al, 1994). If r is defined as the radius of a circle that passes through x and y, r = $\sqrt{(x^2+y^2)}$, so $y^2 + x^2$ can be replaced with r^2 to simplify the equation symbolically. For a simplification in one dimension (Edelstein-Keshet, 1987; Lubina and Levin, 1988; Holmes et al, 1994 Shigesada and Kawasaki, 1997) the solution to the diffusion equation is solved while defining the initial distribution at t=0:

$$n(x,t) = \left(\frac{n_o}{4pDt}\right)\exp\left(-\frac{x^2}{4Dt}\right) \tag{5}$$

This model has limitations in that it estimates a population expansion solely by diffusion without population growth, works best only when the habitat is homogeneous, and must assume all individuals within the population have similar movements. When the population density is extremely low it is difficult to detect the presence of organisms.

Lubina and Levin (1988) suggest that if the scale of observation of sea otters is considerably greater in magnitude than the average length of the individual steps, and there is a large component of stochasticity in their distribution, then a random walk correctly describes their movement through a simple diffusion model. Variance in environmental factors can influence dispersal behavior, and within this model individuals are not presupposed to neglect information about their habitat quality, but rather at a population level, individual movements are indistinguishable from completely random movements.

Diffusion with logistical growth

Skellam introduced the diffusion equation with Malthusian growth added in 1951:

$$\frac{\partial n}{\partial t} = D\left(\frac{\partial^2 n}{\partial x^2} + \frac{\partial^2 n}{\partial y^2}\right) + rn \qquad (6)$$

Like the simple diffusion model, it is possible to write the density at a given distance from the initial introduction:

$$n(r,t) = \frac{n_o}{4pDt}\exp\left(rt - \frac{x^2}{4Dt}\right) \qquad (7)$$

The distribution is Gaussian as is the case for diffusion. The Skellam model can explain spread of a population if it is linear with respect to time. Therefore, it does not consider density dependence influences on the population. An influential application of this theory is that if population growth and movement are constant over time (and there is no advection) the ultimate speed at which the population front proceeds outward from the origin is:

$$V = 2(rD)^{1/2} \qquad (8)$$

Where r is the intrinsic rate of growth of the population (Lubina and Levin, 1988, Shigesada and Kawasaki, 1997). It shows that expansion is due to the combination of growth and diffusion and that without either, there is no advance of the population (Shigesada and Kawasaki, 1997).

For estimating sea otter expansion, Lubina and Levin (1988) therefore utilized a simple diffusion model incorporating local growth rate:

$$\frac{\partial n}{\partial t} = f(n,x,y,) + \frac{\partial^2 (Dn)}{\partial x^2} + \frac{\partial^2 (Dn)}{\partial y^2} - m\frac{\partial x}{\partial n} - v\frac{\partial n}{\partial y} \qquad (9)$$

where n = n(x,y,t) is the population density at time t and location (x,y), D is the habitat dependent determinant of diffusion (which can vary in space), and u and v are variables that measure advective influences. The local growth of the population f(n,x,y,t) can vary in space and time. The movement of otters within their established range and into new habitat areas is limited to within a few kilometers of shore; therefore the model can be simplified to one dimension in the x direction (moving north and south).

Lubina and Levin (1988) analyzed the historical data on the sea otter from 1914–1984 and independently derived the front speed to the north as 1.4km/yr and south as 3.1km/yr. The difference may be attributed to variance in mortality, habitat, or fecundity or perhaps all (Estes, 1996, Siniff and Ralls, 1988). However, the predominant hypothesis is that a difference in mortality governs the growth rate rather than reproduction rate (Estes, 1996). The early invasion spatial distribution was estimated as 2Dt (for one-dimensional space), from which an estimate of the intrinsic growth rate was 0.056/year and the diffusion coefficients obtained were D = 13.5 km^2/year for the northern expansion and D = 54.7 km^2/year for the southern expansion. After substituting these parameters in to the velocity equation, $V = 2(rD)^{1/2}$, predicted front speeds were 1.74 km/year for the north and 3.5 km/year for the south which closely match the actual rates between 1938 and 1972 of 1.4km/year and 3.1km/year respectively (Lubina and Levin, 1988, Shigesada and Kawasaki, 1997). For estimating expansion and density while incorporating the Channel Islands, we assume the population splits evenly between the mainland and island habitats once the otters reach Point Conception.

Table 12 - Population density - Skellam's Model

Year	Block O Density 225- 369km**	Block O Total Populati on	Block Q Density 720 km**	Block Q Total Populati on	Block P Density 369 - 494 km	Block P Total Populati on	Total Population Blocks (O+Q+P)
2000	0.20	52.3	0.21	55.	0.01	2.8	110
2005	0.29	78.2	0.31	83	0.02	4.7	166
2010	0.43	115.3	0.46	123. 1	0.03	7.8	246
2015	0.63	167.8	0.68	180.3	0.05	12.5	361
2020	0.91	241.5	0.98	261.3	0.07	20	523
2025	1.29	344.3	1.41	375.2	0.12	31	750

Population density (otter/km^2) using Skellam's model. Block O Santa Barbara county line to 125 km south. Block Q Channel Islands 720 km. Block P 125-250 km south of Pt Conception
****Assuming the otter population splits at Point Conception and utilizing 3 year running averages of census data**

The results of this model predict the largest population growth in comparison to other models we investigated. The model does neither address density dependence nor habitat dependence that the actual population experiences. Therefore, the model allows unlimited increases in density of individuals per km^2. Coupled with diffusion, the rate of expansion is accelerated to the outward edges of the range. At low values for *t* this model may work well, but considering larger values of *t*, it appears to fail in making reasonable predictions for population growth.

The Fisher model predicts a traveling wave front that explains not only the spatial spread of a population over time but also the population density by using growth to satisfy the logistic equation:

$$\frac{\partial n}{\partial t} = D\left(\frac{\partial^2 n}{\partial x^2} + \frac{\partial^2 n}{\partial y^2}\right) + (r - mn)n \qquad (10)$$

Where r equals intrinsic growth of the population; μ is intraspecific competition; and n is the current population size. Since logistic growth is a non-linear term, this equation cannot be solved explicitly as the Skellam equation.

APPENDIX C - SEA OTTER DIET AND PARTITIONING OF PREY

Studies of "before and after" re-colonization are primary sources of information about the sea otter's diet requirements (Lowry and Pearse, 1973; Estes, Smith, and Palmisano, 1978 Costa, 1978,). According to Costa (1978) approximately 10% of prey items taken from the rocky intertidal areas of Hopkins Marine Life Refuge were abalone (*Haliotis* spp); of which otters gained 26% of their energetic requirements by consuming on average 12 abalone/day. The remaining partitioning of prey consumption was: 37.7% kelp crabs, (*Pugettia producta)*, 11.8% turban snails (*Tegula* spp.); 10.5% sea urchins, (*Stongylocentrotus* spp.); 7.0% rock crab, (*Cancer* spp.); 1.3% clam; 0.6% sea stars, (*Pisaster gigantus)*; and 23% unknown prey. Costa (1978) also performed a caloric content for each prey species (Table 1). Hines and Pearse (1982) conservatively estimated 3% abalone consumption for the otters in a later study of the same area, which support suggestions that prey consumption diversifies with increased length of occupancy.

Wild and Ames (1974) calculated the effect that 100 otters could have on abalone populations over time. In one year (conversion below), 100 sea otters could consume from 230,000 to 460,000 kg. (0.5-1.0 million pounds whole weight) of abalone. It should be noted that the Ebert (1966) and Wild and Ames (1974) percent estimates above are based on numbers consumed (not by weight). Percent by weight would be much higher for abalone than other prey. Conversions reported by Ebert (1968) are as follows:

One 178 mm (7 inch) abalone is equal to .7kg biomass and can be substituted by:

- 2.2 gaper clams
- 3.0 red sea urchins
- 10.7 scallops
- 31.6 purple sea urchins
- 63 mussels

Wild and Ames (1974) calculated a conversion factor to compare sea otter consumption to commercial landings. Landings are based on whole weight which is figured at 22.7kg (50 lb) per dozen. Using a 203mm (8 inch) abalone with 1kg (2.2lb) of biomass as a comparison basis, a dozen abalone's biomass would weigh 12kg (26.4 lb).

$$\frac{22.7kg(wholewt)}{12.0kg(biomass)} = 1.9 = \text{conversion factor}$$

Legal catch size for abalones is 197 mm; therefore a 1.9 conversion factor would be average. For example:

1.9 x 3.3kg = 6.3 kg (whole weight) of abalone per day x 365 days/year x 100 otters

= 229,995kg abalone per year for 100 otters or 2300 kg /otter/year.

For further consideration, a 203 mm abalone is twice the biomass of 153mm abalone and more than 7 times a 102 mm abalone. Therefore, as otters expand their range, larger abalones and/or urchins will be consumed first then a range of sizes will be consumed to match the energy content of larger specimens. Consequently, the potential impact on spawning and recruitment of all prey species may be large (Wild and Ames, 1994).

Ebert (1968) and Costa (1974) both point out that it is useful to compare studies with variable otter occupancy times. In response to habitat quality and food resource changes, the otter switches to a prey with lower or higher caloric content. Study sites with recent otter invasion show a high percentage of abalone consumption compared to the same area many years later (Estes, 1990, Wild and Ames, 1974). Considering that abalone densities in Southern California are very low due to over fishing and a subsequent closure of the fishery, otters are likely to substitute red sea urchin as preferred prey. If we utilize the same approach to red urchin consumption as Wild and Ames (1994), we can estimate the affects 100 otters could have on the Santa Barbara urchin population. 3.75 red urchins or 39.5 purple urchins will substitute for one 203 mm abalone and equal 1kg of biomass. Prey consumption distribution coupled with population estimates for Santa Barbara and Ventura counties are used to the estimate the otter's consumption rate of valuable fisheries over time (Appendix D).

APPENDIX D - FISHERIES

F1: Historic Fishing in California

Fisheries in California had their origin at least 4000 years before Spanish friars ever arrived (McEvoy, 1986). Food was so plentiful that native inhabitants of California had the highest population density of any indigenous peoples north of central Mexico (McEvoy, 1986). This was particularly true of the Chumash and Gabrielino peoples of what is now Santa Barbara and Ventura counties who were described as “the wealthiest, most populous, and most powerful ethnic nationality in aboriginal Southern California.” (McEvoy, 1986)

Fishing remained mainly for subsistence prior to California statehood. The only fishery that gained any commercial importance prior to statehood was that of the sea otter (McEvoy, 1986). The deaths of most Gabrielino and Chumash through European introduced disease and battles with Aleut and Kodiak fur hunters for fishery resources resulted in the end of the Southern California maritime culture. That, coupled with the extirpation of sea otters from California removed predatory pressures on abalone and other mollusks resulting in the abundant supplies immigrant fishers would find decades later (McEvoy, 1986).

As indigenous fisheries were all but eliminated, Chinese and Italian immigrants began to fish the fertile waters of California. The abalone fishery out of San Diego was one of the most important of the Chinese fisheries as 1880 landings were more than 4 million pounds. Such a large commercial fishery would not have been possible in the presence of sea otters (McEvoy, 1986). The developing urchin and abalone fisheries benefited some of the other important commercial and recreational fisheries by eliminating predators of kelp, allowing it to grow and provide food and shelter for other important fish species (McEvoy, 1986). Towards the end of the nineteenth century market forces, environmental changes, and changes in traditional cultures of fishers in California increased the importance of fisheries in local communities. New fisheries emerged in the abundant California waters and fishery management in the state was developed under assumptions of unreasonably high expectations (McEvoy, 1986).

F2: Calculations of Impacts to Fisheries

Tables 13 – 15 summarize calculated impacts to local fisheries due to sea otters note that values in red and in parenthesis are negative impacts). These values were reached using the following methods:

1. Ex-vessel price was calculated for each species for years 1995-1999. Average harvest was also calculated for this time frame. These values were then multiplied to give us the value in Column B for the 5-year average revenue for each fishery. We gathered data on harvest and ex-vessel price from the Pacific States Marine Fisheries Council (PacFIN, 2000).

2. Our projections of sea otter population in each year were multiplied by individual sea otter caloric requirements (from Costa, 1978) to give a total caloric requirement for all sea otters in the area in each year. These calories were then divided among the different species according to the contribution each species of interest makes to the sea otters' diet (also from Costa, 1978). This gave us a meat weight of each species that otters would consume in that year. We replaced abalone consumption with lobster consumption because these species have the same caloric value (Costa, 1978; Pooley & Kawamoto, 1998; Stewart, 2000) and we are assuming that in the relative absence of abalone, otters will switch to a species with similar caloric value.

3. Once we had a value for calories consumed each year from each species we converted this to a total meat weight of each species consumed in each year. These calculations were based on data of caloric content of meat in each species from Costa (1978), Pooley & Kawamoto (1998), and Stewart (2000). We then converted this meat weight to whole weight consumed for each species using Pooley & Kawamoto (1998), Stewart (2000), Ackroyd and Beattie (2001), Mottet (1976), Fallgatter (2001), and ESHA Research in SCOD (2001). The results from these calculations are displayed in Column C.

4. We then took the difference between whole weight of each species consumed in each year (2001-2025) and the whole weight of each species consumed in year 2000 (our baseline) and multiplied this by the 5-year average ex-vessel price for each species. We then subtracted this number from the 5-year average revenue for each species to get the

change in revenue for each fishery. The results of these calculations are displayed in Column D. Please note that in our sea otter population projection at the 5th percentile, otter populations actually decline resulting in an increase in revenue to the fisheries.

5. In some years, the projected change in consumption of prey was greater than the harvest in each fishery. In order to better capture the costs to the fisheries we determined that these "excess calories" should be redistributed to other species. We did this by taking the difference between the whole weight of each species consumed by urchins and the 5-year average whole weight harvest (calculated earlier). We then back calculated the remaining whole weight into calories. These calories were then redistributed to each species according to the percentage each species contributed to the otters' diet (from Costa, 1978). We then calculated the changes to revenue from these "excess calories" and combined it with the change in revenue displayed in Column D to get the value in Column E, which we feel is a more accurate reflection of the impact of sea otters on each fishery. At this point it is important to note that we capped losses to each fishery at a level equivalent to the 5-year average revenue because the fisheries cannot lose more than they are worth.

6. Column F is half of the calculated changes in revenue for each fishery and reflects the changes in income from fishing that may result from competition with sea otters.

Table 13 – Calculated otter impacts to crab fishery in Santa Barbara and Ventura Counties in the absence of zonal management.

A	B	C	D	E	F
Year	5-Year Average Yearly Revenue of Crab Fishery	Whole Weight of Crab Consumed by Sea Otters at Median Population Projection (lb/year)	Changes to Crab Fishery Revenue w/o Redistribution of Excess Calories (losses capped at 5-yr average yearly revenue)	Changes to Crab Fishery Revenue w/ Excess Calories Redistributed to/from other Species (losses capped at 5-yr average yearly revenue)	Changes to Income (50% of Revenue Changes) from Crab Fishery Changes w/ Excess Calories Redistributed
2001	$826,832.21	104,376	($157,029.17)	($157,029.17)	($78,514.58)
2002	$826,832.21	117,423	($302,841.97)	($302,841.97)	($151,420.98)
2003	$826,832.21	127,459	($415,005.66)	($415,005.66)	($207,502.83)
2004	$826,832.21	132,477	($471,087.50)	($471,087.50)	($235,543.75)
2005	$826,832.21	137,495	($527,169.35)	($527,169.35)	($263,584.67)
2006	$826,832.21	137,495	($527,169.35)	($527,169.35)	($263,584.67)
2007	$826,832.21	138,498	($538,385.72)	($538,385.72)	($269,192.86)
2008	$826,832.21	136,491	($515,952.98)	($515,952.98)	($257,976.49)
2009	$826,832.21	134,484	($493,520.24)	($493,520.24)	($246,760.12)
2010	$826,832.21	135,488	($504,736.61)	($504,736.61)	($252,368.30)
2011	$826,832.21	138,498	($538,385.72)	($538,385.72)	($269,192.86)
2012	$826,832.21	142,513	($583,251.19)	($583,251.19)	($291,625.60)
2013	$826,832.21	148,535	($650,549.41)	($651,063.06)	($325,531.53)
2014	$826,832.21	152,549	($695,414.88)	($707,569.11)	($353,784.55)
2015	$826,832.21	156,563	($740,280.36)	($764,075.15)	($382,037.57)
2016	$826,832.21	161,582	($796,362.20)	($826,832.21)	($413,416.10)
2017	$826,832.21	165,596	($826,832.21)	($826,832.21)	($413,416.10)
2018	$826,832.21	170,614	($826,832.21)	($826,832.21)	($413,416.10)
2019	$826,832.21	172,621	($826,832.21)	($826,832.21)	($413,416.10)
2020	$826,832.21	174,629	($826,832.21)	($826,832.21)	($413,416.10)
2021	$826,832.21	176,636	($826,832.21)	($826,832.21)	($413,416.10)
2022	$826,832.21	178,643	($826,832.21)	($826,832.21)	($413,416.10)
2023	$826,832.21	182,657	($826,832.21)	($826,832.21)	($413,416.10)
2024	$826,832.21	184,665	($826,832.21)	($826,832.21)	($413,416.10)
2025	$826,832.21	188,679	($826,832.21)	($826,832.21)	($413,416.10)
				Total Losses Associated With Median Sea Otter Population Projection	($7,982,782.41)
				Losses Discounted at 7%	($3,214,819.27)

Table 14 - Calculated otter impacts to lobster fishery in Santa Barbara and Ventura Counties in the absence of zonal management.

A	B	C	D	E	F
Year	5-Year Average Yearly Revenue of Lobster Fishery	Whole Weight of Lobster Consumed by Sea Otters at Median Population Projection (lb/year)	Changes to Lobster Fishery Revenue w/o Redistribution of Excess Calories (losses capped at 5-yr average yearly revenue)	Changes to Lobster Fishery Revenue w/ Excess Calories Redistributed to/from other Species (losses capped at 5-yr average yearly revenue)	Changes to Income (50% of Revenue Changes) from Lobster Fishery Changes w/ Excess Calories Redistributed
2001	$1,852,166.02	390,535	($448,439.25)	($448,439.25)	($224,219.62)
2002	$1,852,166.02	439,352	($864,847.12)	($864,847.12)	($432,423.56)
2003	$1,852,166.02	476,903	($1,185,160.87)	($1,185,160.87)	($592,580.44)
2004	$1,852,166.02	495,679	($1,345,317.75)	($1,345,317.75)	($672,658.87)
2005	$1,852,166.02	514,455	($1,505,474.62)	($1,505,474.62)	($752,737.31)
2006	$1,852,166.02	514,455	($1,505,474.62)	($1,505,474.62)	($752,737.31)
2007	$1,852,166.02	518,210	($1,537,506.00)	($1,537,506.00)	($768,753.00)
2008	$1,852,166.02	510,700	($1,473,443.25)	($1,473,443.25)	($736,721.62)
2009	$1,852,166.02	503,189	($1,409,380.50)	($1,409,380.50)	($704,690.25)
2010	$1,852,166.02	506,944	($1,441,411.87)	($1,441,411.87)	($720,705.94)
2011	$1,852,166.02	518,210	($1,537,506.00)	($1,537,506.00)	($768,753.00)
2012	$1,852,166.02	533,230	($1,665,631.50)	($1,665,631.50)	($832,815.75)
2013	$1,852,166.02	555,761	($1,852,166.02)	($1,852,166.02)	($926,083.01)
2014	$1,852,166.02	570,782	($1,852,166.02)	($1,852,166.02)	($926,083.01)
2015	$1,852,166.02	585,802	($1,852,166.02)	($1,852,166.02)	($926,083.01)
2016	$1,852,166.02	604,578	($1,852,166.02)	($1,852,166.02)	($926,083.01)
2017	$1,852,166.02	619,599	($1,852,166.02)	($1,852,166.02)	($926,083.01)
2018	$1,852,166.02	638,374	($1,852,166.02)	($1,852,166.02)	($926,083.01)
2019	$1,852,166.02	645,885	($1,852,166.02)	($1,852,166.02)	($926,083.01)
2020	$1,852,166.02	653,395	($1,852,166.02)	($1,852,166.02)	($926,083.01)
2021	$1,852,166.02	660,905	($1,852,166.02)	($1,852,166.02)	($926,083.01)
2022	$1,852,166.02	668,416	($1,852,166.02)	($1,852,166.02)	($926,083.01)
2023	$1,852,166.02	683,436	($1,852,166.02)	($1,852,166.02)	($926,083.01)
2024	$1,852,166.02	690,946	($1,852,166.02)	($1,852,166.02)	($926,083.01)
2025	$1,852,166.02	705,967	($1,852,166.02)	($1,852,166.02)	($926,083.01)
				Total Losses Associated With Median Sea Otter Population Projection	($19,998,875.79)
				Losses Discounted at 7%	($8,446,896.15)

Table 15 - Calculated otter impacts to urchin fishery in Santa Barbara and Ventura Counties in the absence of zonal management.

A	B	C	D	E	F
Year	5-Year Average Yearly Revenue of Sea Urchin Fishery	Whole Weight of Sea Urchin Consumed by Sea Otters at Median Population Projection (lb/year)	Changes to Sea Urchin Fishery Revenue w/o Redistribution of Excess Calories (losses capped at 5-yr average yearly revenue)	Changes to Sea Urchin Fishery Revenue w/ Excess Calories Redistributed to/from other Species (losses capped at 5-yr average yearly revenue)	Changes to Income (50% of Revenue Changes) from Sea Urchin Fishery Changes w/ Excess Calories Redistributed
2001	$8,519,664.28	161,242	($22,573.94)	($22,573.94)	($11,286.97)
2002	$8,519,664.28	181,398	($43,535.45)	($43,535.45)	($21,767.72)
2003	$8,519,664.28	196,902	($59,659.69)	($59,659.69)	($29,829.84)
2004	$8,519,664.28	204,654	($67,721.81)	($67,721.81)	($33,860.90)
2005	$8,519,664.28	212,406	($75,783.93)	($75,783.93)	($37,891.96)
2006	$8,519,664.28	212,406	($75,783.93)	($75,783.93)	($37,891.96)
2007	$8,519,664.28	213,956	($77,396.35)	($77,396.35)	($38,698.18)
2008	$8,519,664.28	210,855	($74,171.50)	($74,171.50)	($37,085.75)
2009	$8,519,664.28	207,755	($70,946.66)	($70,946.66)	($35,473.33)
2010	$8,519,664.28	209,305	($72,559.08)	($72,559.08)	($36,279.54)
2011	$8,519,664.28	213,956	($77,396.35)	($77,396.35)	($38,698.18)
2012	$8,519,664.28	220,158	($83,846.05)	($83,846.05)	($41,923.02)
2013	$8,519,664.28	229,460	($93,520.59)	($93,594.43)	($46,797.22)
2014	$8,519,664.28	235,662	($99,970.29)	($101,717.53)	($50,858.77)
2015	$8,519,664.28	241,864	($106,419.98)	($109,840.64)	($54,920.32)
2016	$8,519,664.28	249,616	($114,482.10)	($119,994.51)	($59,997.26)
2017	$8,519,664.28	255,817	($120,931.80)	($128,716.49)	($64,358.25)
2018	$8,519,664.28	263,569	($128,993.92)	($141,203.48)	($70,601.74)
2019	$8,519,664.28	266,670	($132,218.77)	($146,198.28)	($73,099.14)
2020	$8,519,664.28	269,771	($135,443.62)	($151,193.07)	($75,596.54)
2021	$8,519,664.28	272,872	($138,668.46)	($156,187.87)	($78,093.93)
2022	$8,519,664.28	275,973	($141,893.31)	($161,182.66)	($80,591.33)
2023	$8,519,664.28	282,174	($148,343.01)	($171,172.25)	($85,586.13)
2024	$8,519,664.28	285,275	($151,567.86)	($176,167.05)	($88,083.52)
2025	$8,519,664.28	291,477	($158,017.55)	($186,156.64)	($93,078.32)
				Total Losses Associated With Median Sea Otter Population Projection	($1,322,349.82)
				Losses Discounted at 7%	($498,118.03)

F3: Fisheries Economics

Bionomic Model

Unless managed otherwise, "natural resources are owned in common and exploited under conditions of individualistic competition." (Gordon, 1954) Fisheries are certainly a "common property" resource- meaning that no individual or firm possesses exclusive rights to exploit the fishery (Conrad and Clark, 1987). H.S. Gordon (1954) developed one of the first economic models of fisheries based upon Milner B Schaefer's biological fishery model (Conrad and Clark, 1987).

The Schaefer model lumps together the factors influencing growth of a fish population (recruitment, growth, mortality, predation, etc.) into a single growth rate that is a function of itself and the aquatic environment (Munro, 1981). Environmental factors limit the maximum size of a population; this is the carrying capacity. Considering the aquatic environment as constant, we have a growth function:

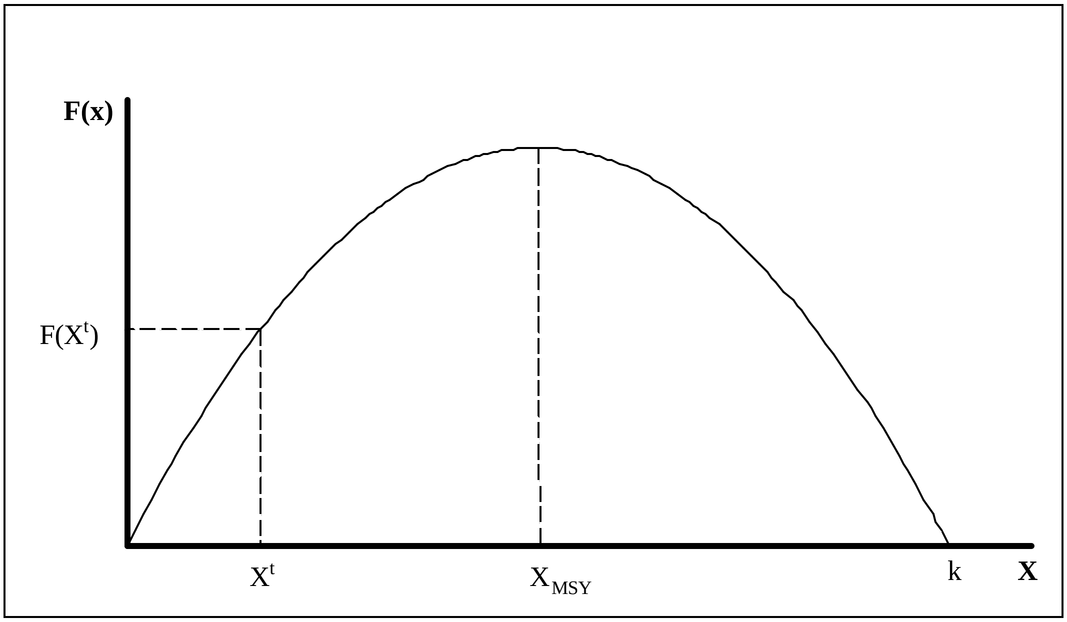
$$\frac{dx}{dt} = F(x) \qquad [1]$$

where x represents the biomass, t represents time, and F(x) is a given function representing the natural growth rate of the biomass. Incorporating k, the carrying capacity, and a constant r into the equation we get the intrinsic growth rate:

$$\frac{dx}{dt} = r(x - \frac{x^2}{k}) \qquad [2]$$

Figure 10 is the resulting graph:

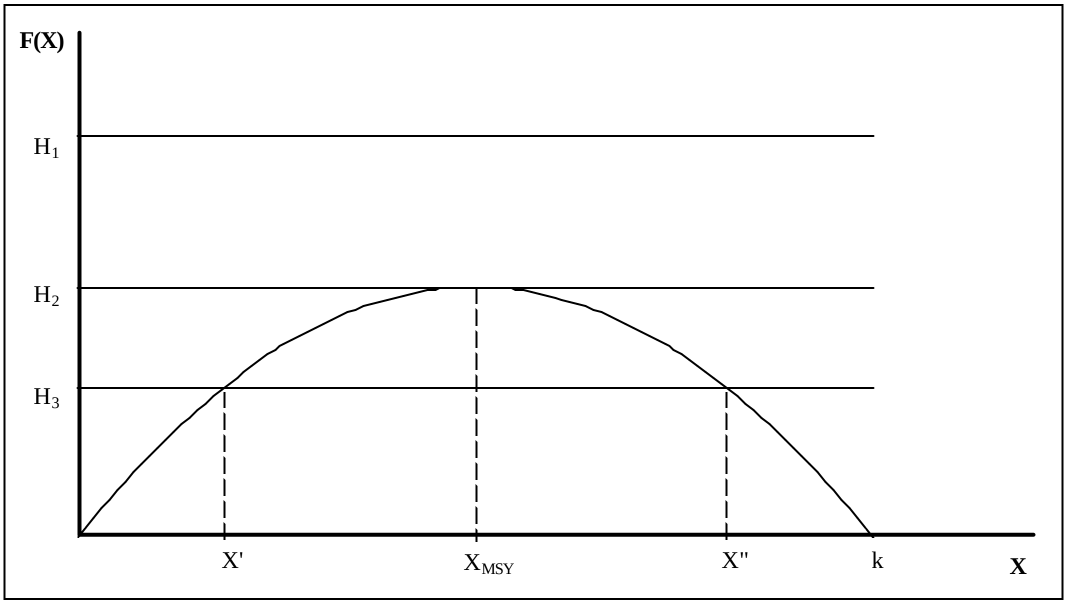
Figure 10 - Sustainable Physical Yield. Adapted from Munro (1981).



The biomass increases at a decreasing rate until it reaches the carrying capacity at which point $F(x) = 0$. $F(x)$ reaches a maximum and then begins to decline, (Munro, 1981)

We now incorporate economic activity (harvest) into this model in order to derive an understanding of bionomic equilibrium-an equilibrium that combines biological mechanics with economic activity (Hartwick and Olewiler, 1986). This can be seen in Figure 11:

Figure 11 - Three different harvest rates for a fishery. Adapted from Hartwick and Olewiler (1986).



We assume that the population is initial in a biological equilibrium at $x = K$. At a harvest rate of H_1 the rate of harvest is above the biological growth function; at each point in time more individuals are being removed than are being replaced. If this level of harvest is maintained the population will eventually reach a population of zero (Hartwick and Olewiler, 1986).

The harvest rate H_2 touches the growth function at its maximum point. X_{MSY} is the point where the surplus growth of the population is at its maximum; this is the maximum sustainable yield (Hartwick and Olewiler, 1986). The MSY occurs at exactly half the carrying capacity. This is the point at which the maximum harvest can be maintained indefinitely, as long as no other exogenous changes occur) (Hartwick and Olewiler, 1986). Although this is the maximum level of harvest that may be sustained, it is not necessarily the economic optimum (Hartwick and Olewiler, 1986). If the initial population of the stock is to the left of x_{MSY} than the population will decline because at each instant the harvest rate exceeds the growth rate (Hartwick and Olewiler, 1986). If however, the initial population is at any point to the right of x_{MSY} the population will decline to x_{MSY} because the harvest is greater than the growth rate. The population reaches equilibrium at the point where the rate of harvest equals the growth rate.

At the harvest rate of H_3 there are two equilibrium points-those points where the harvest intersects the growth function. If the stock is initially at K the harvest H_3 is greater than the growth rate so the population will decline to x''. If the population is at any level above x' then the growth rate is greater than the harvest rate and the population will increase to equilibrium at x''. x'' is a stable equilibrium because if there is any change in the stock size to the right or left, the system will return to equilibrium at x''. If the size of the stock is at any point to the left of x' then the harvest rate is greater than the growth rate and the population will decline to zero (Hartwick and Olewiler, 1986). x' is an unstable equilibrium because if the stock size varies at all it will result in a new equilibrium, either at x'' or at zero (Hartwick and Olewiler, 1986).

After incorporating harvest into our model of a fish population we have a new equation:

$$\frac{dx}{dt} = F(x) - H(t) \qquad [3]$$

where H(t) is the rate of harvest at time t. Steady-state bionomic equilibrium is reached at the point where the growth rate is equal to the rate of harvest. At this point there will be no change in the size of the stock over time (Hartwick and Olewiler, 1986).

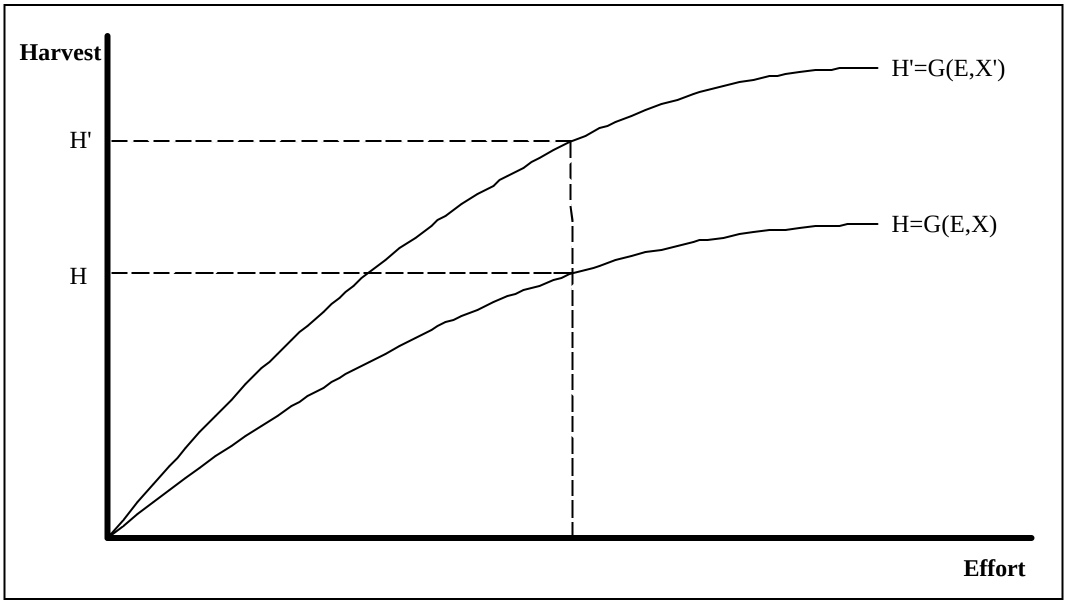
Thus far in the discussion we arbitrarily chose a harvest rate in order to illustrate its relationship to bionomic equilibrium. We must now define a harvest function for the fishery. This requires that we assume the industry is perfectly competitive and all prices are constant over time. This means that the demand curve for fish and the supply curve of factor inputs are perfectly elastic. We are also assuming that there is no discounting of the value of future harvests (Hartwick and Olewiler, 1986). We now define the harvest function H(t) as dependent on two inputs, E(t) and X(t) so that:

$$H(t) = G[E(t), X(t) \qquad [4]$$

E is known as fishing effort and is a measure of some combination of inputs such as capital, labor, materials and/or energy. X refers to stock size at a given time (Hartwick and Olewiler, 1986). It is intuitive at this point to realize that relationship between these three factors. For example, if we hold the stock constant and increase effort the harvest will change; or, if we keep effort constant but the stock size increases, we can see that harvest will change (Hartwick and Olewiler, 1986).

Figure 12 shows an example of this relationship.

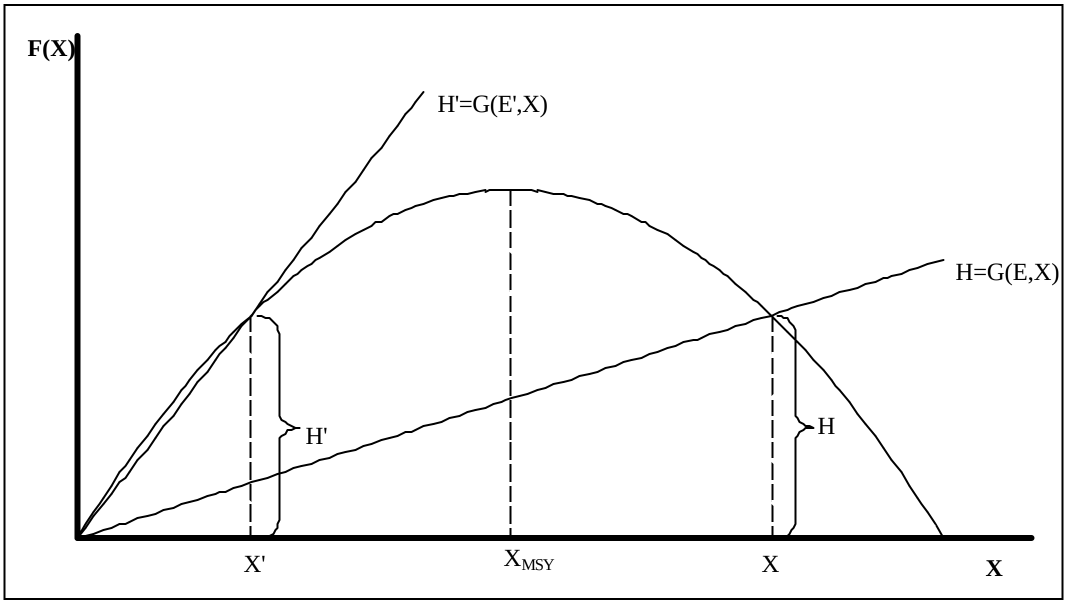
Figure 12 - Two harvest functions for a fishery, assuming constant, but different, stock size. Adapted from Hartwick and Olewiler (1986).



Stock size is held constant and the harvest function is the curve H = G(E,X). As effort is increased, the harvest rises, but at a decreasing rate. This demonstrates the economic principle of the diminishing marginal product of the variable factor (effort) combined with a fixed factor (stock size) (Hartwick and Olewiler, 1986). In this case the fixed stock size should be interpreted as a steady-state fish population, as previously discussed. If we increase the stock of fish to X' we see that the harvest is greater for each unit of effort. We thus have a downward sloping marginal product of effort at a given stock size: each unit of effort results in proportionately smaller harvests (Hartwick and Olewiler, 1986).

Figure 13 is an example where we hold stock size constant, but change effort.

Figure 13 - Steady-state harvests for given levels of effort as a function of the fish stock. Adapted from Hartwick and Olewiler (1986).

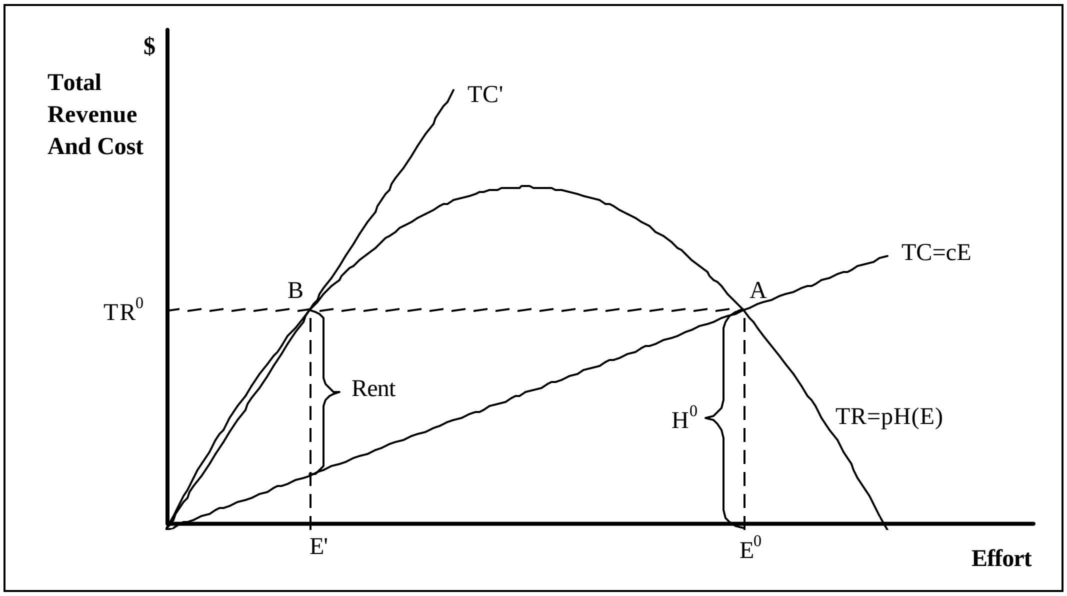


At a given level of effort, the harvest is an increasing function of stock size; as the stock gets larger, the harvest also increases (Hartwick and Olewiler, 1986). The assumption here is that the harvest function is linear. The equilibrium harvest is thus the point at which the growth curve F(*x*) intersects the harvest function H(*t*). This occurs at a stock level of X yielding a harvest of H (Hartwick and Olewiler, 1986).

If we now increase the level of effort to E' the harvest function shifts upward to H'. The steady-state harvest is exactly the same as before, but is now at a stock size of X' which is much lower than stock size X (Hartwick and Olewiler, 1986). In conceptual terms, each unit of additional effort shifts the harvest function upwards-each unit of effort yields greater harvest. However, these greater harvests are depleting the stock. Because of the shape of the biological function, harvest will continue to increase until the steady-state equilibrium is at MSY (the harvest function intersects the growth function at the top of the curve). Further increases in effort will continue to pivot the harvest function until the steady state is to the left of the MSY and catch begins to decline. Catch per unit effort (CPUE) is thus declining and any effort greater than E' will result in a total catch that is less than the total catch at E (Hartwick and Olewiler, 1986). It is economically inefficient to operate to the left of MSY because more effort than necessary is used to catch a certain amount of fish (Hartwick and Olewiler, 1986).

We must now determine the total revenues and costs for the fishery to determine the industry equilibrium. Each unit of effort E has a cost c, therefore the equation for total cost is TC = cE. We can see this line in Figure 14.

Figure 14 - Common property equilibrium occurs where TR=TC. Adapted from Hartwick and Olewiler (1986).

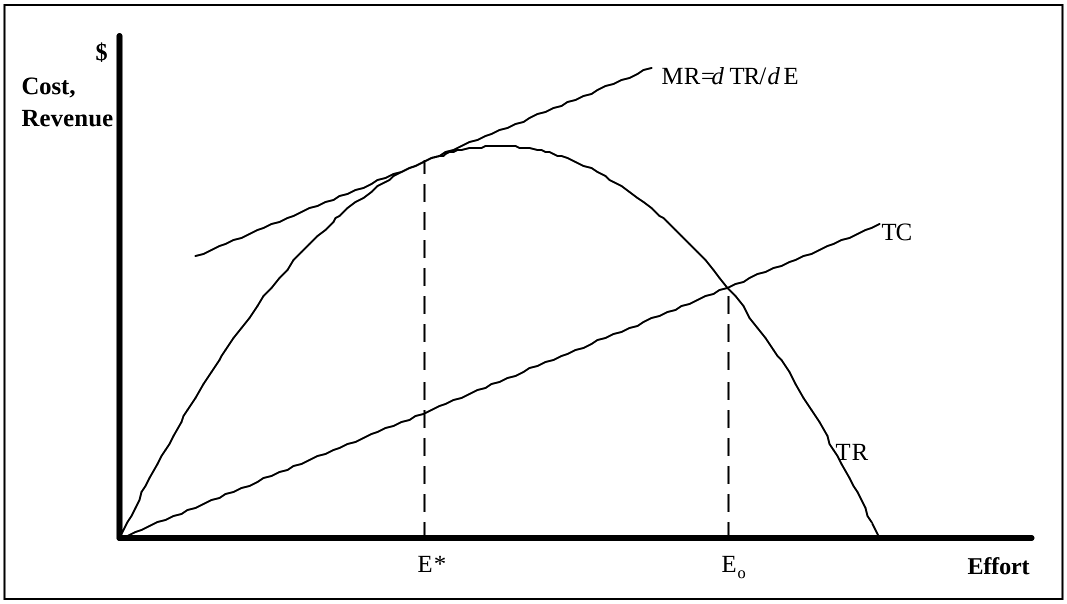


Total Revenues are the price of the fish times the level of harvest (TR = pH). If we normalize the price to a value equal to 1 we get a total revenue curve that is identical to the biological production function in Figure 13. Thus, once we know the equilibrium level of total revenue we know the equilibrium harvest and thus determine the steady state stock size that must support the harvest (Hartwick and Olewiler, 1986).

We can see from Figure 14 that at a level of effort E' total revenue exceeds total costs and so an excess rent (profit) exists. In an open access fishery, firms will enter the industry to capitalize on this excess profit; effort will increase to E^o, the point where TR = TC. At this point all of the rent has been dissipated and economically rational firms will not expend any additional effort (Hartwick and Olewiler, 1986).

Figure 15 once again displays Gordon's model of a common-property fishery. We are still assuming fish price p and effort cost c to be constant.

Figure 15 - Gordon's Model of the common-property fishery. Adapted from Conrad and Clark (1987).



In this case, the equilibrium point at which TC = TR is given as E_o. Gordon argues that the optimum level of effort would be at $E = E^*$ where marginal revenue MR is equal to marginal cost; this level of effort is the point at which a line parallel to the total cost line intersects the revenue curve (Conrad and Clark, 1987). At E^* resource rent TR-TC is maximized; however, at $E = E_o$ this rent is totally dissipated. Also, since $E_o > E_{MSY}$ the fish stock will also be seriously depleted (Conrad and Clark, 1987). An effort level where $E > E_o$ will not happen because fishers would be losing money and would leave the industry. At a level of effort where $E < E_o$ fishers will be making more than their opportunity costs and additional fishermen will be attracted to the fishery (Conrad and Clark, 1987).

From this discussion it should be clear that any fishery that has no limits to harvest or where limits are set at a point where the necessary level of effort would be greater than the point where TR = TC is going to dissipate the rent, and the net profit of the entire fishery will be zero.

APPENDIX E - HEDONIC PRICE MODEL VARIABLES

Dependent Variables: Tourism

The tourism data used in this model came from a report entitled California Travel Impacts by County, 1992-1998 published by California Tourism in March 2000. All of the tourist variables have seven replicates: one for each year between (and including) 1992 and 1998.

Destination Spending: The total of all expenditures by travelers in the county except expenditures for air transportation and travel arrangements. This includes all local and state taxes paid directly by travelers, but do not include income or corporate taxes. Destination spending is further subdivided into 6 subcategories.

Accommodations: Expenditures on accommodations including hotels, motels, B&Bs, campgrounds, etc.

Eating-Drinking: Expenditures on food and drink purchased prepared (i.e. food purchased in a restaurant).

Food Stores: Expenditures on food and drink purchased unprepared (i.e. food purchased in a grocery store).

Ground Transport: Expenditures on all forms of ground transport including trains, buses, rental cars, and any related expenditures such as gasoline.

Recreation: Expenditures on recreational activities.

Retail Sales: Expenditures on retail items.

Total Payroll: Payments to wage and salary workers attributable to travel expenditures.

Total Employment: All employment associated with Total Payroll. This includes full- and part-time positions. Employment is also broken down into six subgroups. Each of these subgroups corresponds to one of the subgroups within the expenditures. They are: Accommodations, Eating-Drinking, Food Stores, Ground Transport, Recreation, and Retail Sales.

Total Taxes: All tax receipts related to travel expenditures. Total Taxes is broken down into two subgroups. Although state corporate and income taxes are not included in the Destination Spending variable, some of the state taxes and all of the local taxes are included. Therefore, this variable cannot be aggregated with Destination Spending.

Local Taxes: Tax receipts for counties and municipalities associated with travel expenditures. Includes local sales and transient occupancy taxes.

State Taxes: Tax receipts for the state associated with travel expenditures. Includes state sales, gasoline, and corporate income taxes as well as personal income taxes associated with tourism related employment.

Independent Variables: County Characteristics

Weather: We used a total of ten different variables to capture any affect that climate may play in tourism. These variables were average high temperature, average low temperature, average precipitation, average snowfall, and average snow depth for both February and August. We used the two different time periods in order to capture seasonal variations. We gathered this data from the Western Regional Climate Center's Local Climate Data Summaries (found at http://www.wrcc.dri.edu/ summary/lcd.html) using climate summaries nearest the county seat.

Area: The area of each county in square miles.

Population: The number of people living within the county per year from 1992 to 1998. We gained this data using a report query through the U.S. Department of Commerce' Bureau of Economic Analysis web page (found at http://www.bea.doc.gov/bea/regional/reis). The data is based on 1990 census information with projected populations for the years 1992 through 1998.

Per Capita Income: The average salary earned per person within the county. We gathered this data from the same source as the population variable.

Coastal Access: The number of coastal access sites within the county. We obtained this data from the California Coastal Access Guide (California Coastal Commission, 1997).

International Airport: The presence or absence of an international airport in the county.

Distance to International Airport: The driving distance from the county seat to the nearest international airport. We obtained this data by mapping the shortest driving route from the county seat to the airport (http://www.mapquest.com/).

Tourist Attractions: The number of tourist attractions that had more than 1 million visitors in 1999 (California Tourism, 2000). This includes amusement parks, museums, aquariums, and state and national parks.

Otter Population: The number of sea otters per year. We obtained this data from the US Geological Survey and it includes spring counts of independent sea otters and sea otter pups.

Dummy variables: We included one dummy variable in the model for each year between 1992 and 1997 and one dummy variable for counties with international tourism significance (Los Angeles, Orange, San Diego, and San Francisco).

APPENDIX F - MULTIPLE RESGRESSION ANALYSIS

Total Destination Spending

```
Call: lm(formula = TotDestSpend ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)

Residuals:
    Min     1Q Median    3Q  Max
 -559.2 -143.6 -34.22 107.1 1925

Coefficients:
                               Value Std. Error    t value   Pr(>|t|)
               (Intercept)  1138.5990  537.3896     2.1188     0.0348
               DummySthCst  -321.4106   92.3774    -3.4793     0.0006
                Population     0.0007    0.0000    29.5737     0.0000
            Area..mi..sq..     0.0460    0.0075     6.1024     0.0000
           PerCapitaIncome     0.0155    0.0043     3.5951     0.0004
             CoastalAccess     9.8537    3.3879     2.9085     0.0038
                  OtterPop     0.3796    0.1069     3.5502     0.0004
     International.Airport   345.7595   86.5206     3.9963     0.0001
Distance.from.Int..Airport    -2.1285    0.4253    -5.0042     0.0000
                 AHFebTemp    37.9616    8.4777     4.4778     0.0000
                 ALFebTemp   -45.8949   10.8803    -4.2182     0.0000
                  APrecFeb     8.1201    9.9920     0.8127     0.4169
              ASnowFallFeb   -35.4419   16.6695    -2.1261     0.0341
             ASnowDepthFeb    50.3287   34.6451     1.4527     0.1471
                 AHAugTemp   -22.8773    4.9650    -4.6077     0.0000
                 ALAugTemp    17.8194    7.0232     2.5372     0.0116
                  APrecAug   286.0945  166.8350     1.7148     0.0872
        TouristAttractions   -61.4535   34.0275    -1.8060     0.0717
              DummyTourism  1168.4876   66.5456    17.5592     0.0000
                   Dummy92   -34.7309   31.1928    -1.1134     0.2662
                   Dummy93   -41.1523   30.8846    -1.3325     0.1835
                   Dummy94   -37.6082   30.5864    -1.2296     0.2196
                   Dummy95   -41.0526   30.2006    -1.3593     0.1748
                   Dummy96   -32.7126   29.8522    -1.0958     0.2739
                   Dummy97    -8.9709   29.5783    -0.3033     0.7618
              DummyNrthCst  -114.6443   62.2549    -1.8415     0.0663

Residual standard error: 317.7 on 380 degrees of freedom
Multiple R-Squared: 0.9584
F-statistic: 350.2 on 25 and 380 degrees of freedom, the p-value is 0
```

Accommodation Spending

```
Call: lm(formula = Accom ~ DummySthCst + Population + Area..mi..sq.. + PerCapitaIncome
+ CoastalAccess + OtterPop + International.Airport + Distance.from.Int..Airport +
AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb + ASnowDepthFeb + AHAugTemp +
ALAugTemp + APrecAug + TouristAttractions + DummyTourism + Dummy92 + Dummy93 + Dummy94
+ Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data = CountyData2000, na.action =
na.exclude)
```

```
Residuals:
    Min     1Q Median    3Q   Max
 -166.6 -31.53 -2.798 18.75 326.8

Coefficients:
                              Value Std. Error   t value  Pr(>|t|)
              (Intercept)  432.6687  108.7989     3.9768    0.0001
               Population    0.0001    0.0000    20.1462    0.0000
           Area..mi..sq..    0.0008    0.0015     0.5315    0.5954
          PerCapitaIncome    0.0046    0.0009     5.3137    0.0000
            CoastalAccess   -1.4624    0.6859    -2.1321    0.0336
                 OtterPop    0.1499    0.0216     6.9225    0.0000
    International.Airport   71.5704   17.5168     4.0858    0.0001
Distance.from.Int..Airport   -0.2639    0.0861    -3.0649    0.0023
               AHFebTemp     4.8016    1.7164     2.7975    0.0054
               ALFebTemp   -10.9517    2.2028    -4.9717    0.0000
                APrecFeb     0.2595    2.0230     0.1283    0.8980
            ASnowFallFeb    -7.7226    3.3749    -2.2883    0.0227
           ASnowDepthFeb     8.7303    7.0142     1.2447    0.2140
               AHAugTemp    -4.0232    1.0052    -4.0024    0.0001
               ALAugTemp     5.4860    1.4219     3.8582    0.0001
                APrecAug    12.6094   33.7771     0.3733    0.7091
      TouristAttractions   -20.0225    6.8891    -2.9064    0.0039
            DummyTourism   305.1931   13.4727    22.6527    0.0000
                 Dummy92   -14.4601    6.3152    -2.2897    0.0226
                 Dummy93   -15.4942    6.2528    -2.4779    0.0136
                 Dummy94   -15.2316    6.1925    -2.4597    0.0144
                 Dummy95   -14.7359    6.1144    -2.4100    0.0164
                 Dummy96   -11.6062    6.0438    -1.9203    0.0556
                 Dummy97    -4.9579    5.9884    -0.8279    0.4082
            DummyNrthCst    36.3965   12.6040     2.8877    0.0041
             DummySthCst     4.5892   18.7026     0.2454    0.8063

Residual standard error: 64.32 on 380 degrees of freedom
Multiple R-Squared: 0.942
F-statistic: 246.7 on 25 and 380 degrees of freedom, the p-value is 0
```

Eating-Drinking Spending

```
Call: lm(formula = EatDrink ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
    Min     1Q Median   3Q   Max
 -107.9 -25.64 -6.689 18.1 355.3

Coefficients:
                              Value Std. Error   t value  Pr(>|t|)
              (Intercept)  218.2274   98.9428     2.2056    0.0280
               Population    0.0001    0.0000    25.0044    0.0000
           Area..mi..sq..    0.0079    0.0014     5.6615    0.0000
          PerCapitaIncome    0.0030    0.0008     3.7486    0.0002
            CoastalAccess    1.7040    0.6238     2.7318    0.0066
                 OtterPop    0.0749    0.0197     3.8031    0.0002
    International.Airport   58.8926   15.9299     3.6970    0.0003
Distance.from.Int..Airport   -0.3760    0.0783    -4.8010    0.0000
```

```
              AHFebTemp    6.9423    1.5609     4.4477    0.0000
              ALFebTemp   -8.9197    2.0033    -4.4526    0.0000
               APrecFeb    1.6486    1.8397     0.8961    0.3708
           ASnowFallFeb   -6.6443    3.0691    -2.1649    0.0310
          ASnowDepthFeb    9.0314    6.3788     1.4158    0.1576
              AHAugTemp   -4.2871    0.9141    -4.6898    0.0000
              ALAugTemp    3.4218    1.2931     2.6462    0.0085
               APrecAug   47.0866   30.7172     1.5329    0.1261
     TouristAttractions  -10.7423    6.2651    -1.7146    0.0872
           DummyTourism  214.3582   12.2522    17.4955    0.0000
                Dummy92   -7.3605    5.7431    -1.2816    0.2008
                Dummy93   -9.3203    5.6864    -1.6391    0.1020
                Dummy94   -8.7927    5.6315    -1.5613    0.1193
                Dummy95   -9.4087    5.5605    -1.6921    0.0915
                Dummy96   -7.8790    5.4963    -1.4335    0.1525
                Dummy97   -3.4941    5.4459    -0.6416    0.5215
           DummyNrthCst  -19.7875   11.4622    -1.7263    0.0851
            DummySthCst  -56.7643   17.0083    -3.3374    0.0009

Residual standard error: 58.5 on 380 degrees of freedom
Multiple R-Squared: 0.9499
F-statistic: 288.2 on 25 and 380 degrees of freedom, the p-value is 0
```

Food Store Spending

```
Call: lm(formula = FoodSto ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
   Min     1Q Median    3Q   Max
 -45.2 -9.785 -1.152 6.906 142.6

Coefficients:
                              Value Std. Error  t value Pr(>|t|)
               (Intercept) -26.1489  35.1263    -0.7444   0.4571
                  OtterPop  -0.0003   0.0070    -0.0471   0.9624
                Population   0.0001   0.0000    38.2318   0.0000
            Area..mi..sq..   0.0045   0.0005     9.1067   0.0000
           PerCapitaIncome   0.0006   0.0003     2.0002   0.0462
             CoastalAccess   1.7524   0.2214     7.9134   0.0000
     International.Airport  19.8357   5.6554     3.5074   0.0005
Distance.from.Int..Airport  -0.1399   0.0278    -5.0305   0.0000
                 AHFebTemp   2.6382   0.5541     4.7609   0.0000
                 ALFebTemp  -1.6549   0.7112    -2.3270   0.0205
                  APrecFeb   0.4477   0.6531     0.6855   0.4935
              ASnowFallFeb  -1.3981   1.0896    -1.2831   0.2002
             ASnowDepthFeb   2.8082   2.2646     1.2401   0.2157
                 AHAugTemp  -1.2240   0.3245    -3.7716   0.0002
                 ALAugTemp   0.3474   0.4591     0.7567   0.4497
                  APrecAug  27.3097  10.9051     2.5043   0.0127
        TouristAttractions  -1.8050   2.2242    -0.8115   0.4176
              DummyTourism  45.7236   4.3497    10.5118   0.0000
                   Dummy92  -3.2458   2.0389    -1.5919   0.1122
                   Dummy93  -3.6211   2.0188    -1.7937   0.0737
                   Dummy94  -2.4422   1.9993    -1.2215   0.2226
```

```
                  Dummy95  -2.6646   1.9741    -1.3498   0.1779
                  Dummy96  -2.2150   1.9513    -1.1351   0.2570
                  Dummy97  -0.9428   1.9334    -0.4876   0.6261
             DummyNrthCst -26.0028   4.0693    -6.3900   0.0000
              DummySthCst -39.5205   6.0382    -6.5451   0.0000

Residual standard error: 20.77 on 380 degrees of freedom
Multiple R-Squared: 0.9666
F-statistic: 439.7 on 25 and 380 degrees of freedom, the p-value is 0
```

Ground Transportation

```
Call: lm(formula = GrndTrans ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
    Min  1Q Median    3Q   Max
 -103.3 -26 -6.404 20.12 396.8

Coefficients:
                              Value Std. Error   t value  Pr(>|t|)
               (Intercept)  110.0769  104.6224    1.0521    0.2934
               DummySthCst  -92.6928   17.9846   -5.1540    0.0000
                  OtterPop    0.0309    0.0208    1.4844    0.1385
                Population    0.0001    0.0000   27.6395    0.0000
            Area..mi..sq..    0.0119    0.0015    8.1341    0.0000
           PerCapitaIncome    0.0022    0.0008    2.5892    0.0100
             CoastalAccess    3.6211    0.6596    5.4902    0.0000
     International.Airport   71.4284   16.8444    4.2405    0.0000
Distance.from.Int..Airport   -0.4503    0.0828   -5.4378    0.0000
                 AHFebTemp    7.6312    1.6505    4.6236    0.0000
                 ALFebTemp   -6.5836    2.1182   -3.1081    0.0020
                  APrecFeb    1.1102    1.9453    0.5707    0.5685
              ASnowFallFeb   -5.5532    3.2453   -1.7111    0.0879
             ASnowDepthFeb    9.0561    6.7449    1.3427    0.1802
                 AHAugTemp   -4.0885    0.9666   -4.2298    0.0000
                 ALAugTemp    2.1113    1.3673    1.5441    0.1234
                  APrecAug   73.8423   32.4805    2.2734    0.0236
        TouristAttractions   -9.5780    6.6247   -1.4458    0.1491
              DummyTourism  180.3498   12.9555   13.9207    0.0000
                   Dummy92   -0.6048    6.0728   -0.0996    0.9207
                   Dummy93   -0.6082    6.0128   -0.1011    0.9195
                   Dummy94    0.5274    5.9548    0.0886    0.9295
                   Dummy95    0.0780    5.8796    0.0133    0.9894
                   Dummy96    1.6116    5.8118    0.2773    0.7817
                   Dummy97    5.8487    5.7585    1.0157    0.3104
              DummyNrthCst  -49.5846   12.1202   -4.0911    0.0001

Residual standard error: 61.86 on 380 degrees of freedom
Multiple R-Squared: 0.954
F-statistic: 314.9 on 25 and 380 degrees of freedom, the p-value is 0
```

Recreation Spending

```
Call: lm(formula = Rec ~ DummySthCst + Population + Area..mi..sq.. + PerCapitaIncome +
CoastalAccess + OtterPop + International.Airport + Distance.from.Int..Airport +
AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb + ASnowDepthFeb + AHAugTemp +
ALAugTemp + APrecAug + TouristAttractions + DummyTourism + Dummy92 + Dummy93 + Dummy94
+ Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data = CountyData2000, na.action =
na.exclude)


Residuals:
    Min     1Q Median    3Q   Max
 -131.4 -18.59 -3.565 11.53 212.5

Coefficients:
                               Value Std. Error   t value  Pr(>|t|)
               (Intercept)  125.8496   60.9169     2.0659    0.0395
                  OtterPop    0.0386    0.0121     3.1884    0.0015
                Population    0.0001    0.0000    38.8889    0.0000
            Area..mi..sq..    0.0050    0.0009     5.8451    0.0000
           PerCapitaIncome    0.0014    0.0005     2.8323    0.0049
             CoastalAccess    1.6849    0.3840     4.3872    0.0000
     International.Airport   17.6732    9.8077     1.8020    0.0723
Distance.from.Int..Airport   -0.2447    0.0482    -5.0747    0.0000
                 AHFebTemp    4.9853    0.9610     5.1876    0.0000
                 ALFebTemp   -6.9228    1.2334    -5.6130    0.0000
                  APrecFeb    3.1306    1.1327     2.7639    0.0060
              ASnowFallFeb   -5.5266    1.8896    -2.9247    0.0037
             ASnowDepthFeb    7.5760    3.9273     1.9291    0.0545
                 AHAugTemp   -2.9318    0.5628    -5.2092    0.0000
                 ALAugTemp    2.5703    0.7961     3.2285    0.0014
                  APrecAug   32.3092   18.9119     1.7084    0.0884
        TouristAttractions   -3.3916    3.8573    -0.8793    0.3798
              DummyTourism  135.6493    7.5434    17.9825    0.0000
                   Dummy92   -6.1097    3.5359    -1.7279    0.0848
                   Dummy93   -6.8838    3.5010    -1.9662    0.0500
                   Dummy94   -6.2784    3.4672    -1.8108    0.0710
                   Dummy95   -6.5035    3.4235    -1.8997    0.0582
                   Dummy96   -5.4215    3.3840    -1.6021    0.1100
                   Dummy97   -2.3988    3.3529    -0.7154    0.4748
              DummyNrthCst  -24.5073    7.0570    -3.4727    0.0006
               DummySthCst  -48.1286   10.4716    -4.5961    0.0000

Residual standard error: 36.02 on 380 degrees of freedom
Multiple R-Squared: 0.9691
F-statistic: 476.2 on 25 and 380 degrees of freedom, the p-value is 0
```

Retail Spending

```
Call: lm(formula = Retail ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
    Min     1Q Median    3Q   Max
 -164.5 -36.77 -8.396 27.01 556.2
```

```
Coefficients:
                               Value Std. Error   t value  Pr(>|t|)
              (Intercept)  174.6066  144.7961     1.2059    0.2286
                 OtterPop    0.0694    0.0288     2.4091    0.0165
               Population    0.0002    0.0000    30.1748    0.0000
            Area..mi..sq..    0.0158    0.0020     7.7922    0.0000
          PerCapitaIncome    0.0037    0.0012     3.1550    0.0017
            CoastalAccess    2.8037    0.9128     3.0714    0.0023
    International.Airport   98.8408   23.3124     4.2398    0.0000
Distance.from.Int..Airport   -0.6065    0.1146    -5.2923    0.0000
                AHFebTemp   10.4547    2.2843     4.5768    0.0000
                ALFebTemp   -9.5372    2.9316    -3.2532    0.0012
                 APrecFeb    1.4725    2.6923     0.5470    0.5847
             ASnowFallFeb   -7.7164    4.4915    -1.7180    0.0866
            ASnowDepthFeb   12.3726    9.3349     1.3254    0.1858
                AHAugTemp   -5.7870    1.3378    -4.3258    0.0000
                ALAugTemp    3.2398    1.8924     1.7120    0.0877
                 APrecAug   92.5951   44.9526     2.0598    0.0401
       TouristAttractions  -14.2437    9.1685    -1.5536    0.1211
             DummyTourism  252.8162   17.9303    14.1000    0.0000
                  Dummy92  -12.2919    8.4047    -1.4625    0.1444
                  Dummy93  -12.3646    8.3216    -1.4858    0.1382
                  Dummy94  -11.0376    8.2413    -1.3393    0.1813
                  Dummy95  -11.9868    8.1374    -1.4731    0.1416
                  Dummy96   -9.9684    8.0435    -1.2393    0.2160
                  Dummy97   -4.3094    7.9697    -0.5407    0.5890
             DummyNrthCst  -37.6579   16.7742    -2.2450    0.0253
              DummySthCst  -91.8928   24.8905    -3.6919    0.0003

Residual standard error: 85.61 on 380 degrees of freedom
Multiple R-Squared: 0.9558
F-statistic: 329.1 on 25 and 380 degrees of freedom, the p-value is 0
```

Total Payroll

```
Call: lm(formula = TotPay ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
    Min     1Q Median    3Q   Max
 -200.7 -73.83  2.172 47.94 578.7

Coefficients:
                               Value Std. Error   t value  Pr(>|t|)
              (Intercept)  622.3560  184.6696     3.3701    0.0008
                 OtterPop    0.0093    0.0367     0.2522    0.8010
               Population    0.0003    0.0000    43.1419    0.0000
            Area..mi..sq..   -0.0009    0.0026    -0.3288    0.7425
          PerCapitaIncome    0.0074    0.0015     5.0131    0.0000
            CoastalAccess    4.7494    1.1642     4.0795    0.0001
    International.Airport   42.4242   29.7321     1.4269    0.1544
Distance.from.Int..Airport   -0.8633    0.1462    -5.9066    0.0000
                AHFebTemp    4.3889    2.9133     1.5065    0.1328
                ALFebTemp  -28.1836    3.7389    -7.5379    0.0000
                 APrecFeb    2.7355    3.4337     0.7967    0.4261
             ASnowFallFeb  -16.0353    5.7283    -2.7993    0.0054
```

ASnowDepthFeb	11.8879	11.9055	0.9985	0.3187
AHAugTemp	-5.3250	1.7062	-3.1210	0.0019
ALAugTemp	15.3991	2.4135	6.3804	0.0000
APrecAug	-30.7398	57.3315	-0.5362	0.5921
TouristAttractions	-122.2838	11.6933	-10.4576	0.0000
DummyTourism	289.3625	22.8679	12.6537	0.0000
Dummy92	9.2429	10.7192	0.8623	0.3891
Dummy93	4.5279	10.6132	0.4266	0.6699
Dummy94	2.3536	10.5108	0.2239	0.8229
Dummy95	-1.6403	10.3782	-0.1581	0.8745
Dummy96	-2.6363	10.2585	-0.2570	0.7973
Dummy97	-0.9920	10.1643	-0.0976	0.9223
DummyNrthCst	75.7822	21.3934	3.5423	0.0004
DummySthCst	-119.2756	31.7448	-3.7573	0.0002

```
Residual standard error: 109.2 on 380 degrees of freedom
Multiple R-Squared: 0.9493
F-statistic: 284.9 on 25 and 380 degrees of freedom, the p-value is 0
```

Total Employment

```
Call: lm(formula = EmpTotal ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
   Min    1Q Median   3Q   Max
 -7107 -2237 -578.6 1699 20029
```

Coefficients:

	Value	Std. Error	t value	Pr(>|t|)
(Intercept)	21913.3768	6694.9350	3.2731	0.0012
OtterPop	2.7833	1.3322	2.0892	0.0374
Population	0.0109	0.0003	38.6241	0.0000
Area..mi..sq..	0.4277	0.0939	4.5557	0.0000
PerCapitaIncome	0.1963	0.0536	3.6638	0.0003
CoastalAccess	217.5062	42.2069	5.1533	0.0000
International.Airport	2904.0214	1077.8950	2.6942	0.0074
Distance.from.Int..Airport	-34.5764	5.2990	-6.5251	0.0000
AHFebTemp	346.9263	105.6177	3.2847	0.0011
ALFebTemp	-894.4215	135.5494	-6.5985	0.0000
APrecFeb	173.3513	124.4828	1.3926	0.1646
ASnowFallFeb	-627.9253	207.6728	-3.0236	0.0027
ASnowDepthFeb	654.4693	431.6179	1.5163	0.1303
AHAugTemp	-274.4369	61.8548	-4.4368	0.0000
ALAugTemp	430.2622	87.4972	4.9174	0.0000
APrecAug	1463.3935	2078.4725	0.7041	0.4818
TouristAttractions	-2631.7897	423.9228	-6.2082	0.0000
DummyTourism	14117.9775	829.0419	17.0293	0.0000
Dummy92	-303.4788	388.6079	-0.7809	0.4353
Dummy93	-293.8989	384.7680	-0.7638	0.4454
Dummy94	-198.7410	381.0534	-0.5216	0.6023
Dummy95	-208.4895	376.2470	-0.5541	0.5798
Dummy96	-185.3218	371.9068	-0.4983	0.6186
Dummy97	-67.1942	368.4936	-0.1823	0.8554
DummyNrthCst	-147.8747	775.5879	-0.1907	0.8489
DummySthCst	-5304.9486	1150.8610	-4.6095	0.0000

```
Residual standard error: 3958 on 380 degrees of freedom
Multiple R-Squared: 0.9617
F-statistic: 381.6 on 25 and 380 degrees of freedom, the p-value is 0
```

Accommodation Employment

```
Call: lm(formula = EmpAccom ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
   Min     1Q Median    3Q  Max
 -3175 -415.5 -45.77 291.7 5290

Coefficients:
                               Value Std. Error    t value   Pr(>|t|)
               (Intercept)  6619.4835  1610.7505     4.1096     0.0000
               DummySthCst  -526.9481   276.8884    -1.9031     0.0578
                  OtterPop     1.6618     0.3205     5.1846     0.0000
                Population     0.0016     0.0001    23.9043     0.0000
            Area..mi..sq..     0.0363     0.0226     1.6081     0.1086
           PerCapitaIncome     0.0434     0.0129     3.3690     0.0008
             CoastalAccess     9.5502    10.1547     0.9405     0.3476
     International.Airport   818.3248   259.3334     3.1555     0.0017
Distance.from.Int..Airport    -4.9459     1.2749    -3.8794     0.0001
                 AHFebTemp    69.5811    25.4108     2.7382     0.0065
                 ALFebTemp  -166.3671    32.6122    -5.1014     0.0000
                  APrecFeb    13.2528    29.9496     0.4425     0.6584
              ASnowFallFeb  -125.7077    49.9645    -2.5159     0.0123
             ASnowDepthFeb   141.4652   103.8440     1.3623     0.1739
                 AHAugTemp   -61.6392    14.8818    -4.1419     0.0000
                 ALAugTemp    82.8835    21.0512     3.9372     0.0001
                  APrecAug   198.9085   500.0647     0.3978     0.6910
        TouristAttractions  -259.3189   101.9926    -2.5425     0.0114
              DummyTourism  4393.8323   199.4612    22.0285     0.0000
                   Dummy92   -88.4725    93.4961    -0.9463     0.3446
                   Dummy93  -115.2135    92.5722    -1.2446     0.2141
                   Dummy94  -122.2469    91.6786    -1.3334     0.1832
                   Dummy95  -131.7266    90.5222    -1.4552     0.1464
                   Dummy96  -112.1903    89.4779    -1.2538     0.2107
                   Dummy97   -41.7057    88.6568    -0.4704     0.6383
              DummyNrthCst   158.9332   186.6006     0.8517     0.3949

Residual standard error: 952.3 on 380 degrees of freedom
Multiple R-Squared: 0.9495
F-statistic: 286 on 25 and 380 degrees of freedom, the p-value is 0
```

Eating-Drinking Employment

```
Call: lm(formula = EmpEatDrink ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
```

```
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
   Min     1Q Median    3Q  Max
 -2197 -584.8 -132.2 410.5 8347

Coefficients:
                              Value Std. Error    t value   Pr(>|t|)
              (Intercept)  4057.8122  2256.1356     1.7986     0.0729
                 OtterPop     1.5293     0.4489     3.4065     0.0007
               Population     0.0020     0.0001    20.4769     0.0000
           Area..mi..sq..     0.2324     0.0316     7.3468     0.0000
          PerCapitaIncome     0.0370     0.0181     2.0519     0.0409
            CoastalAccess    57.7578    14.2234     4.0608     0.0001
    International.Airport  1000.6598   363.2414     2.7548     0.0062
Distance.from.Int..Airport    -9.2971     1.7857    -5.2064     0.0000
                AHFebTemp   143.1631    35.5923     4.0223     0.0001
                ALFebTemp  -174.4949    45.6790    -3.8200     0.0002
                 APrecFeb    51.8931    41.9496     1.2370     0.2168
             ASnowFallFeb  -154.1056    69.9840    -2.2020     0.0283
            ASnowDepthFeb   218.5803   145.4515     1.5028     0.1337
                AHAugTemp   -87.3707    20.8445    -4.1915     0.0000
                ALAugTemp    61.9553    29.4858     2.1012     0.0363
                 APrecAug  1279.1089   700.4274     1.8262     0.0686
       TouristAttractions  -103.2712   142.8583    -0.7229     0.4702
             DummyTourism  3958.5602   279.3800    14.1691     0.0000
                  Dummy92  -239.8375   130.9575    -1.8314     0.0678
                  Dummy93  -207.2041   129.6635    -1.5980     0.1109
                  Dummy94  -148.7105   128.4117    -1.1581     0.2476
                  Dummy95  -130.3360   126.7920    -1.0280     0.3046
                  Dummy96   -99.8282   125.3294    -0.7965     0.4262
                  Dummy97   -54.9570   124.1792    -0.4426     0.6583
             DummyNrthCst  -790.3217   261.3665    -3.0238     0.0027
              DummySthCst -1431.7389   387.8303    -3.6917     0.0003

Residual standard error: 1334 on 380 degrees of freedom
Multiple R-Squared: 0.9351
F-statistic: 219.2 on 25 and 380 degrees of freedom, the p-value is 0
```

Food Store Employment

```
Call: lm(formula = EmpFoodSto ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
    Min     1Q Median    3Q   Max
 -253.7 -50.16 -3.693 36.03 630.8

Coefficients:
                            Value Std. Error   t value  Pr(>|t|)
              (Intercept)  -94.6770  175.7735   -0.5386    0.5905
                 OtterPop   -0.0029    0.0350   -0.0843    0.9328
               Population    0.0002    0.0000   30.8565    0.0000
           Area..mi..sq..    0.0165    0.0025    6.7032    0.0000
```

```
          PerCapitaIncome    0.0034    0.0014     2.4459    0.0149
            CoastalAccess   11.4861    1.1081    10.3653    0.0000
     International.Airport  166.0843   28.2998     5.8687    0.0000
Distance.from.Int..Airport   -0.6668    0.1391    -4.7932    0.0000
               AHFebTemp    10.9700    2.7730     3.9561    0.0001
               ALFebTemp   -11.3169    3.5588    -3.1800    0.0016
                APrecFeb     3.7642    3.2683     1.1517    0.2502
            ASnowFallFeb   -10.8615    5.4524    -1.9921    0.0471
           ASnowDepthFeb    16.7380   11.3320     1.4771    0.1405
               AHAugTemp    -6.4666    1.6240    -3.9819    0.0001
               ALAugTemp     4.5817    2.2972     1.9945    0.0468
                APrecAug    94.8387   54.5697     1.7379    0.0830
      TouristAttractions   -21.0338   11.1300    -1.8898    0.0595
            DummyTourism   191.9176   21.7662     8.8172    0.0000
                 Dummy92   -20.4650   10.2028    -2.0058    0.0456
                 Dummy93   -18.6739   10.1020    -1.8485    0.0653
                 Dummy94   -12.4332   10.0044    -1.2428    0.2147
                 Dummy95    -9.4169    9.8783    -0.9533    0.3410
                 Dummy96    -5.9098    9.7643    -0.6052    0.5454
                 Dummy97    -0.6141    9.6747    -0.0635    0.9494
             DummyNrthCst -154.0266   20.3628    -7.5641    0.0000
              DummySthCst -229.6276   30.2155    -7.5997    0.0000

Residual standard error: 103.9 on 380 degrees of freedom
Multiple R-Squared: 0.9566
F-statistic: 334.7 on 25 and 380 degrees of freedom, the p-value is 0
```

Ground Transportation Employment

```
Call: lm(formula = EmpGrndTrans ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
    Min     1Q Median    3Q  Max
 -509.4 -136.4 -9.938 99.57 1901

Coefficients:
                               Value Std. Error    t value   Pr(>|t|)
              (Intercept)  1021.7853  483.2854     2.1142     0.0351
                 OtterPop     0.1150    0.0962     1.1957     0.2326
               Population     0.0002    0.0000    10.6015     0.0000
           Area..mi..sq..     0.0586    0.0068     8.6499     0.0000
          PerCapitaIncome     0.0125    0.0039     3.2206     0.0014
            CoastalAccess    14.1720    3.0468     4.6515     0.0000
     International.Airport   639.5905   77.8097     8.2199     0.0000
Distance.from.Int..Airport    -2.2114    0.3825    -5.7813     0.0000
                AHFebTemp    27.7650    7.6242     3.6417     0.0003
                ALFebTemp   -24.6962    9.7849    -2.5239     0.0120
                 APrecFeb    -2.5812    8.9860    -0.2873     0.7741
             ASnowFallFeb   -27.3385   14.9912    -1.8236     0.0690
            ASnowDepthFeb    46.6373   31.1571     1.4968     0.1353
                AHAugTemp   -18.0523    4.4651    -4.0430     0.0001
                ALAugTemp     8.5013    6.3161     1.3460     0.1791
                 APrecAug   301.7547  150.0381     2.0112     0.0450
       TouristAttractions   -92.5305   30.6016    -3.0237     0.0027
```

```
           DummyTourism  1078.7321    59.8458    18.0252     0.0000
                Dummy92   -35.6804    28.0523    -1.2719     0.2042
                Dummy93   -28.7134    27.7751    -1.0338     0.3019
                Dummy94   -20.8108    27.5070    -0.7566     0.4498
                Dummy95   -23.4053    27.1600    -0.8618     0.3894
                Dummy96   -15.5836    26.8467    -0.5805     0.5619
                Dummy97    -2.1751    26.6003    -0.0818     0.9349
           DummyNrthCst  -163.0512    55.9871    -2.9123     0.0038
            DummySthCst  -347.2143    83.0769    -4.1794     0.0000

Residual standard error: 285.7 on 380 degrees of freedom
Multiple R-Squared: 0.9302
F-statistic: 202.5 on 25 and 380 degrees of freedom, the p-value is 0
```

Recreation Employment

```
Call: lm(formula = EmpRec ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
   Min     1Q Median    3Q  Max
 -1887 -244.5 -14.75 222.3 3206

Coefficients:
                               Value Std. Error    t value   Pr(>|t|)
            (Intercept)  1533.2193   948.4342     1.6166     0.1068
               OtterPop    -0.0924     0.1887    -0.4898     0.6246
             Population     0.0011     0.0000    28.4549     0.0000
         Area..mi..sq..     0.1112     0.0133     8.3611     0.0000
        PerCapitaIncome     0.0141     0.0076     1.8642     0.0631
          CoastalAccess    44.8695     5.9792     7.5043     0.0000
  International.Airport    58.2113   152.6994     0.3812     0.7033
Distance.from.Int..Airport  -3.9803     0.7507    -5.3023     0.0000
              AHFebTemp    82.8829    14.9623     5.5395     0.0000
              ALFebTemp   -95.8303    19.2025    -4.9905     0.0000
               APrecFeb    57.7031    17.6348     3.2721     0.0012
           ASnowFallFeb   -84.2839    29.4199    -2.8649     0.0044
          ASnowDepthFeb   105.8923    61.1449     1.7318     0.0841
              AHAugTemp   -46.5524     8.7626    -5.3126     0.0000
              ALAugTemp    28.2904    12.3952     2.2824     0.0230
               APrecAug   563.0642   294.4456     1.9123     0.0566
     TouristAttractions   -40.5748    60.0548    -0.6756     0.4997
           DummyTourism  2066.5586   117.4458    17.5959     0.0000
                Dummy92  -107.0353    55.0519    -1.9443     0.0526
                Dummy93   -74.5245    54.5079    -1.3672     0.1724
                Dummy94   -32.8319    53.9817    -0.6082     0.5434
                Dummy95   -16.2472    53.3008    -0.3048     0.7607
                Dummy96   -16.7139    52.6860    -0.3172     0.7512
                Dummy97    -4.6447    52.2024    -0.0890     0.9291
           DummyNrthCst  -692.0479   109.8732    -6.2986     0.0000
            DummySthCst -1170.6284   163.0361    -7.1802     0.0000

Residual standard error: 560.7 on 380 degrees of freedom
Multiple R-Squared: 0.9572
F-statistic: 340 on 25 and 380 degrees of freedom, the p-value is 0
```

Retail Employment

```
Call: lm(formula = EmpRetail ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
   Min     1Q Median    3Q  Max
 -1383 -238.4 -11.98 198.3 3797

Coefficients:
                               Value Std. Error    t value   Pr(>|t|)
              (Intercept)   624.1438   990.3360     0.6302     0.5289
                 OtterPop     0.3797     0.1971     1.9266     0.0548
               Population     0.0008     0.0000    20.0767     0.0000
           Area..mi..sq..     0.1125     0.0139     8.0986     0.0000
          PerCapitaIncome     0.0154     0.0079     1.9424     0.0528
            CoastalAccess    27.6572     6.2434     4.4299     0.0000
    International.Airport   468.5164   159.4457     2.9384     0.0035
Distance.from.Int..Airport    -4.0139     0.7838    -5.1208     0.0000
                AHFebTemp    67.2659    15.6233     4.3055     0.0000
                ALFebTemp   -48.2658    20.0509    -2.4072     0.0166
                 APrecFeb     4.1726    18.4139     0.2266     0.8209
             ASnowFallFeb   -47.1903    30.7196    -1.5362     0.1253
            ASnowDepthFeb    84.0657    63.8463     1.3167     0.1887
                AHAugTemp   -35.3659     9.1498    -3.8652     0.0001
                ALAugTemp    13.5698    12.9429     1.0484     0.2951
                 APrecAug   695.1611   307.4542     2.2610     0.0243
       TouristAttractions   -30.2370    62.7080    -0.4822     0.6300
             DummyTourism  1436.4658   122.6345    11.7134     0.0000
                  Dummy92   -99.7660    57.4841    -1.7355     0.0835
                  Dummy93   -90.3263    56.9161    -1.5870     0.1133
                  Dummy94   -75.1058    56.3666    -1.3325     0.1835
                  Dummy95   -71.5804    55.6556    -1.2861     0.1992
                  Dummy96   -51.8367    55.0136    -0.9423     0.3467
                  Dummy97   -15.6034    54.5087    -0.2863     0.7748
             DummyNrthCst  -431.6831   114.7274    -3.7627     0.0002
              DummySthCst  -663.8292   170.2390    -3.8994     0.0001

Residual standard error: 585.5 on 380 degrees of freedom
Multiple R-Squared: 0.9323
F-statistic: 209.2 on 25 and 380 degrees of freedom, the p-value is 0
```

Total Taxes

```
Call: lm(formula = TaxTotal ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
```

```
    Min     1Q Median    3Q   Max
 -49.15 -12.31 -3.137 8.463 137.3

Coefficients:
                              Value Std. Error   t value  Pr(>|t|)
               (Intercept)  124.9332  41.7759     2.9906    0.0030
                  OtterPop    0.0321   0.0083     3.8556    0.0001
                Population    0.0001   0.0000    33.8252    0.0000
             Area..mi..sq..   0.0028   0.0006     4.7308    0.0000
           PerCapitaIncome    0.0013   0.0003     3.9355    0.0001
             CoastalAccess    0.3796   0.2634     1.4413    0.1503
     International.Airport   27.9604   6.7260     4.1571    0.0000
Distance.from.Int..Airport   -0.1692   0.0331    -5.1184    0.0000
                 AHFebTemp    2.6160   0.6590     3.9694    0.0001
                 ALFebTemp   -4.2012   0.8458    -4.9670    0.0000
                  APrecFeb    0.5761   0.7768     0.7417    0.4587
              ASnowFallFeb   -2.8481   1.2959    -2.1979    0.0286
             ASnowDepthFeb    3.2938   2.6933     1.2230    0.2221
                 AHAugTemp   -1.7728   0.3860    -4.5931    0.0000
                 ALAugTemp    1.8604   0.5460     3.4075    0.0007
                  APrecAug   14.2308  12.9695     1.0972    0.2732
        TouristAttractions   -9.2524   2.6452    -3.4977    0.0005
              DummyTourism   97.2494   5.1732    18.7988    0.0000
                   Dummy92   -2.8644   2.4249    -1.1813    0.2382
                   Dummy93   -3.6656   2.4009    -1.5267    0.1277
                   Dummy94   -3.4873   2.3777    -1.4666    0.1433
                   Dummy95   -3.0512   2.3478    -1.2996    0.1945
                   Dummy96   -2.4006   2.3207    -1.0344    0.3016
                   Dummy97   -0.5934   2.2994    -0.2581    0.7965
              DummyNrthCst    1.9379   4.8396     0.4004    0.6891
               DummySthCst  -19.4977   7.1813    -2.7151    0.0069

Residual standard error: 24.7 on 380 degrees of freedom
Multiple R-Squared: 0.9612
F-statistic: 376.2 on 25 and 380 degrees of freedom, the p-value is 0
```

Local Taxes

```
Call: lm(formula = TaxLoc ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
    Min     1Q  Median    3Q  Max
 -28.77 -4.491 -0.4746 2.908 56.6

Coefficients:
                             Value Std. Error  t value Pr(>|t|)
               (Intercept)  85.7388  16.3474     5.2448   0.0000
                  OtterPop   0.0194   0.0033     5.9537   0.0000
                Population   0.0000   0.0000    31.4412   0.0000
            Area..mi..sq..   0.0002   0.0002     0.7945   0.4274
           PerCapitaIncome   0.0006   0.0001     4.4584   0.0000
             CoastalAccess  -0.4405   0.1031    -4.2746   0.0000
     International.Airport  13.4067   2.6320     5.0938   0.0000
Distance.from.Int..Airport  -0.0459   0.0129    -3.5468   0.0004
                 AHFebTemp   0.7136   0.2579     2.7672   0.0059
```

```
                ALFebTemp  -1.8037   0.3310    -5.4497   0.0000
                 APrecFeb   0.1255   0.3040     0.4129   0.6799
              ASnowFallFeb  -1.0415   0.5071    -2.0538   0.0407
             ASnowDepthFeb   0.8612   1.0539     0.8172   0.4144
                AHAugTemp  -0.6474   0.1510    -4.2864   0.0000
                ALAugTemp   0.9054   0.2136     4.2379   0.0000
                 APrecAug  -1.5948   5.0751    -0.3142   0.7535
        TouristAttractions  -4.4941   1.0351    -4.3416   0.0000
              DummyTourism  49.8279   2.0243    24.6146   0.0000
                  Dummy92  -1.3037   0.9489    -1.3739   0.1703
                  Dummy93  -1.6752   0.9395    -1.7830   0.0754
                  Dummy94  -1.7021   0.9304    -1.8294   0.0681
                  Dummy95  -1.5899   0.9187    -1.7306   0.0843
                  Dummy96  -1.1754   0.9081    -1.2943   0.1963
                  Dummy97  -0.3755   0.8998    -0.4173   0.6767
              DummyNrthCst  10.1939   1.8938     5.3828   0.0000
               DummySthCst   2.3704   2.8101     0.8435   0.3995

Residual standard error: 9.665 on 380 degrees of freedom
Multiple R-Squared: 0.9598
F-statistic: 362.5 on 25 and 380 degrees of freedom, the p-value is 0
```

State Taxes

```
Call: lm(formula = TaxSta ~ DummySthCst + Population + Area..mi..sq.. +
PerCapitaIncome + CoastalAccess + OtterPop + International.Airport +
Distance.from.Int..Airport + AHFebTemp + ALFebTemp + APrecFeb + ASnowFallFeb +
ASnowDepthFeb + AHAugTemp + ALAugTemp + APrecAug + TouristAttractions + DummyTourism +
Dummy92 + Dummy93 + Dummy94 + Dummy95 + Dummy96 + Dummy97 + DummyNrthCst, data =
CountyData2000, na.action = na.exclude)


Residuals:
    Min     1Q Median   3Q   Max
 -28.48 -7.676 -2.403 5.04 99.68

Coefficients:
                             Value Std. Error  t value Pr(>|t|)
              (Intercept)  39.1997  27.2494     1.4386   0.1511
                 OtterPop   0.0127   0.0054     2.3464   0.0195
               Population   0.0000   0.0000    33.0313   0.0000
            Area..mi..sq..   0.0026   0.0004     6.7717   0.0000
           PerCapitaIncome   0.0007   0.0002     3.3565   0.0009
             CoastalAccess   0.8208   0.1718     4.7781   0.0000
     International.Airport  14.5441   4.3872     3.3151   0.0010
Distance.from.Int..Airport  -0.1234   0.0216    -5.7209   0.0000
                AHFebTemp   1.8998   0.4299     4.4193   0.0000
                ALFebTemp  -2.3973   0.5517    -4.3453   0.0000
                 APrecFeb   0.4516   0.5067     0.8914   0.3733
              ASnowFallFeb  -1.8069   0.8453    -2.1377   0.0332
             ASnowDepthFeb   2.4325   1.7568     1.3847   0.1670
                AHAugTemp  -1.1247   0.2518    -4.4674   0.0000
                ALAugTemp   0.9555   0.3561     2.6829   0.0076
                 APrecAug  15.7887   8.4597     1.8663   0.0628
        TouristAttractions  -4.7676   1.7254    -2.7632   0.0060
              DummyTourism  47.4185   3.3743    14.0527   0.0000
                  Dummy92  -1.5711   1.5817    -0.9933   0.3212
                  Dummy93  -2.0039   1.5661    -1.2795   0.2015
                  Dummy94  -1.7846   1.5509    -1.1507   0.2506
                  Dummy95  -1.4765   1.5314    -0.9641   0.3356
                  Dummy96  -1.2372   1.5137    -0.8173   0.4143
```

```
         Dummy97  -0.2343   1.4998    -0.1562   0.8760
    DummyNrthCst  -8.2580   3.1568    -2.6160   0.0093
     DummySthCst -21.8813   4.6842    -4.6713   0.0000

Residual standard error: 16.11 on 380 degrees of freedom
Multiple R-Squared: 0.9575
F-statistic: 342.8 on 25 and 380 degrees of freedom, the p-value is 0
```

APPENDIX G - SEA OTTER MANAGEMENT

Management jurisdiction

Government agencies commit themselves to a number of objectives of both a development and a conservation nature. For example: the goal of developing fisheries to meet nutritional needs, while taking into account traditional knowledge and small-scale fisheries, and protecting endangered marine species and ecological sensitive areas. The Endangered Species Act's primary objective is to protect endangered and threatened species while restoring them to a sustainable population status (Clark, 1996). Within the jurisdiction of the ESA, the Secretary of the Interior empowers the U.S. Fish and Wildlife Service (the Service, USFWS) to oversee the protection of wildlife and plants that are found to be at risk. The National Marine Fisheries Service (NFMS), with the exception of birds, is the governing agency over marine life. The southern sea otter, West Indian manatee, and sea turtles are exceptions where jurisdiction resides with the USFWS.

In 1977, the USFWS listed the southern sea otter as threatened (Benz, 1996). Under the ESA a "threatened" status is sought because of one of the following: the present or threatened destruction, modification or curtailment of the species habitat; over utilization for commercial, recreational, scientific, or educational purposes; disease or predation; the inadequacy of existing regulatory mechanisms, or other natural or man-made factors affecting the species survival (Clark, 1996). The southern sea otter was listed because of its small population and range size and the risk of catastrophic events such as oil spills, which has the potential to eliminate the small population (Benz, 1996). Recovery is the ultimate goal of The ESA, which mandates that the USFWS develop recovery plans for species that are listed as threatened or endangered. These plans require the maintenance of secure, optimal self-sustaining (OSP) wild populations of species with the minimal investment of resources (USFWS, 1996). If a species population falls below 60% the OSP, which for the sea otter is 2650 individuals, it is designated as "endangered." Although both designations are given full protection under section 9 of the Endangered Species Act (1972) from "take" which is defined as "harass, harm, pursue, hunt, shoot wound, kill, trap, capture, or collect, or attempt to engage in such conduct," there is however, a legal distinction in protocol between threatened versus endangered classification (Clark, 1996). General prohibitions stand for endangered but not for threatened. Section 4(d) requires regulations for threatened to be as strict as section 9 or less if full protection is not deemed necessary. This opens up the ability of section 7, which allows issuance of incidental take for federal agencies.

The 1996 USFWS Recovery plan outlined the criteria for the southern sea otter population to be considered for delisting under the Endangered Species Act are: (A) Threatened: The southern sea otter population should be considered threatened under the Endangered Species Act if- 1) the average population level over a 3-year period is greater than 1,850 animals, but fewer than 2,650 animals; or 2) the probability of the population declining below 2,650 animals in a specified period of time (e.g., 10 years) is greater than 0.05. (B) 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 2,650 animals. Furthermore, the MMPA mandates that populations of marine mammals smaller than the OSP level be listed as depleted, subject to a petition process. Although legislation does not provide the specific criteria, a customary management practice has been to set a minimum OSP size at 60% of carrying capacity (K) (VanBlaricom, 1996, DeMaster et al, 1996). Table 10 lists the estimated carrying capacities for the southern sea otter according to habitat type (USFWS Recovery Plan, 1996).

The Recovery Plan

In 1979, recognizing that the population had not increased in size since 1973, USFWS initiated a recovery plan for the sea otter that was approved in 1982. The plan addressed the otter's taxonomic status as well as effects on shellfish fisheries and the oil industry (Benz, 1996). The goals of the recovery plan were to: (1) minimize risk to otters from oil related accidents; (2) establish at least one breeding colony located outside the current range; (3) minimize vandalism and incidental take; (4) monitor the recovery of the species; and (5) incorporate the recovery plan into local coastal governments (Benz, 1996).

At the time of the drafting of the recovery plan the sea otter was experiencing a decline in numbers. The California Department of Fish and Game suggested the population was at carrying capacity while the USFWS suggested it was mortality that was hampering the growth rate (Benz, 1996). The reduced rate was later attributed to incidental take of animals in set net fisheries. USFWS reported between 1982 and 1984 an average of 80 otters per year were accidentally drowned in commercial fishing nets and was likely responsible for the lack of increase in the population (Clark, 1996, Benz, 1996). State legislation curtailed set net fishing within the otter's range and until recently, the population experienced a steady increase of about 5% per year. The primary focus of the 1982 recovery plan was to establish a second population that would aid in the recovery of the species if an oil spill event took place.

Because of potential devastation to the population in the event of an oil spill, and the population decline in the early 80's, the USFWS determined that translocation was the most reasonable and effective recovery plan (Benz, 1996). In addition, under this plan, the provisions for the MMPA to determine the carrying capacity of the species would also be met. The translocation of a species as part of a recovery plan is authorized under the ESA in section 16 U.S.C. 1539(j) (2) (A) and establishment of an experimental population under 16 U.S.C. 1533 (d) section 10(a)(1)(A), however, there was no provision under the MMPA for "take" under which translocation of the otters would need to be considered. The proposal of translocation and management actions required Congress to pass legislation (Public Law. 99-625) that specifically authorized the USFWS management of the process as an amendment that satisfied the MMPA.

Public law 99-625

In the early 60's a controversy arose as to whether the cause of the red abalone decline was due to human or sea otter overexploitation (Kenyon, 1968, VanBlaricom, 1996)). This prompted the California state senate to direct the CDFG to determine the feasibility of containing the sea otter population in an effort to protect the existing recreational and commercial abalone fisheries (Wendell. 1996). Since enlistment of the southern sea otter in1977, many thought the species in need of protection, while others considered it a socioeconomic menace (VanBlaricom, 1996). The preemption of state management by the Marine Mammal Protection Act in 1972 greatly complicated the efforts of the California Department of Fish and Game (CDFG) to find a solution for the sea otter-shellfishery conflicts (Wendell, 1996). The ESA's inability to consider the socioeconomic impacts of the recovery of the species contributed to polarization within the sea otter-shellfish conflict. Public Law 98-364, July 17, 1984, (98 Stat. 442), as amended, clarified provisions concerning marine mammals (see Marine Mammal Protection Act of 1972) and provided for the translocation of California sea otters as a protective measure for both the otter as well as the fisheries it could impact (Wendell, 1996, Clark, 1996, VanBlaricom, 1996).

Public Law 99-625, enacted in 1987, regulated the USFWS to develop a translocation plan that mandated the inclusion of the following: (1) the number, age and sex of otters translocated; (2) all methods associated with the translocation and release; (3) designation of a "translocation zone" where the experimental population would reside; (4) designation of a "management zone" which would enclose the translocation zone but would neither include the existing range nor areas that would allow for expansion of the home range of the mainland otters and subsequent recovery of the species (5) develop ways to segregate the experimental population with an adequate funding system; (6) detailed accounting of the relationship of the experimental population to the recovery of the species and future section 7 determinations for both the experimental and mainland populations; and (7) make a provision that would enable the state to cooperate with the USFWS in the administration of the plan. The intent of a management zone was to limit sea otter impacts to the local shellfisheries and other marine resources (Benz, 1996; USFWS Recovery Plan, 1996). Designated in the "no otter zone," was the removal of otters utilizing non-lethal means, without formal section 7 consultations required, whereby incidental take from legal activities would not be considered a take under the ESA or MMPA (Benz, 1996). Under section 6 of the ESA, USFWS attained assistance from the CDFG under a cooperative agreement. The Memorandum of Understanding instructed the agencies with respect to funding, responsibilities, containment, and logistics of the translocation. Section 6 designates USFWS as responsible for 75% of the funding for the cooperative plan and federal congressional appropriations were applied. CDFG received funds from the ESA under section 6 (Benz, 1996).

Translocation Results

A final rule (50 C.F.R. 17.84) was published by the USFWS on August 11, 1987 that revealed San Nicolas Island as the translocation zone for the experimental otter population (Benz, 1996) with a management zone that was all other areas south of Point Conception (Figure 2). Between 1987 and 1990, 139 otters were translocated to San Nicolas from the mainland population. Of the 139, only 61 are accounted for. Three died shortly after release on San Nicolas and an additional three died within the boundaries of the management zone Thirty-seven have returned at least once to the parent population range, and eleven were captured in the management zone and returned to the parent population (Benz, 1996). The remaining eleven otters took up residency on the island and currently total about 20 otters. There is a vast amount of prey and numerous areas of protection to support the new population on San Nicolas (US Fish and

Wildlife Service, 1986). The population is reproducing but it is not increasing, therefore it remains significantly below the OSP of about 500 animals. With only 5-6 pups born a year and high pre-weaning mortality, the fate of the experimental population is uncertain and far from original expectations of success; establishing a viable population in 5 years and reaching carrying capacity in 10-15 years (Benz, 1996).

Zonal Management

Zonal management sought to strike a balance between the natural resources extracted from the nearshore environment, particularly, the interests of the shellfisheries with the protection of a threatened marine mammal (Draft Translocation Plan, 1986, USFWS Biological Opinion, 2000). The USFWS and CDFG cooperated in surveying, capturing, and relocating all otters that tried to colonize within the management zone south of Point Conception (Benz, 1996). Captured animals were released to the northern part of the range in areas below carrying capacity to thwart otters returning to the management zone. Since 1987, 20 independent sea otters have been captured and released, but not without problems. Animals released back into established areas received aggressive attacks and two other animals expiring shortly after a second capture and release. The USFWS is concerned whether containment can be achieved without lethal ramifications (Benz, 1996, USFWS Draft Recovery Plan, 1996). With increasing experience and knowledge of the sea otter and its habitat, it has been necessary to investigate the modification of the containment and management of the California population.

Revised Recovery Plan

The magnitude of damage due to the Exxon Valdez oil spill tragedy of 1989 illustrated that the San Nicolas translocation plan would not offer the protection that was estimated in the 1982 Recovery Plan (Benz, 1996, USFWS, 1996). In addition to the minimal success of the translocation maneuver, funds were diverted to additional listed species, and compounded with otter fatalities; the translocation of otters from the management zone was halted in 1993(Marine Mammal Commission meeting, 1998, Benz, 1996, USFWS, 2000). In addition, failure to resume the containment program was based on record numbers of otters moving south of Point Conception, exposure of the otters to environmental contaminants and diseases, and the effects of the capture and release program to the population as a whole.

During the late 1980s translocation to San Nicolas Island, eight sea otters died while either in captivity, immediately upon release, or within a short period after release. Though better capture and release techniques have been developed in the interim, the U.S. Fish and Wildlife Service takes the position that in order for the species to fully recover, it should be allowed to expand its range into former habitats (USFWS, 1996). A revised Recovery Plan was initiated in 1996 that takes into account all the new developments pertaining to the otter management.

Currently, as declared by P.L. 99-625 the USFWS is to fully investigate the failure criteria outlined in Federal Registry rules for the containment program prior to declaring the program a failure; a draft evaluation was released March of 1999 (Draft evaluation of the translocation, 1999). If the U.S. Fish and Wildlife Service after consultation with the Marine Mammal Commission can declare the Translocation Experiment a failure, the "management zone" (California waters south of Pt. Conception) no longer exists with respects to relocating otters. Federal rules require that the experimental population and the "management zone" be cleared of sea otters if the Translocation Experiment is declared a failure (USFWS, 1999). The USFWS does not consider the San Nicolas population a significant contribution to the preservation or recovery of the species. A move to declare the program a failure is based on failure criteria 2 being met whereby: less than 25 otters persist on the island after 3 years and the reason for emigration and or mortality cannot be identified or remedied (USFWS, 1999). A recently generated biological opinion neither addressed whether the containment program is a threat to the population, nor does it address the efficiency of the methods of capture or the effects the otter has on the nearshore fisheries. An Environmental Impact Statement by the USFWS is forthcoming and should address these issues (Sanders, pers com.).

Public Law 99-625, 100 Stat. 3500

Within the regulations of Public Law 99-625 at 50 CFR 1(d)(8),” The Translocation would generally be considered to have failed if one or more of the following conditions exists:’

Criteria 1 If after the first year following initiation of translocation or any subsequent year, no translocated otters remain within the translocation zone, and the reason for emigration or mortality cannot be identified and /or remedied.

Criteria 2 If within three years from the initial transplant, fewer than25 otters remain, and the reason for emigration or mortality cannot be identified or remedied. Criteria 3 If after two years following the completion of the translocation phase, the experimental population is declining at a significant rate, and the translocated otters are not showing signs of successful reproduction (i.e. no pupping is observed); however, termination of the project under this and the previous criterion may be delayed, if reproduction is occurring, and the degree of dispersal into the management or no-otter zone would be acceptable to the service and the affected State.

Criteria 4 If the Service determines, in consultation with the affected State and Marine Mammal Commission that the sea otters are dispersing from the translocation zone and becoming established within the management zone in sufficient numbers to demonstrate that containment cannot be successfully accomplished. The standard is not intended to apply to situations in which individuals or small numbers of otters are sighted within the management zone or temporarily manage to elude capture. Instead it is meant to be applied when it becomes apparent that, over time (one year or more), otters are relocating from the translocation zone in such numbers that: 1) an independent breeding colony is likely to become established within the management zone or 2) they could cause economic damage to fishery resources within the management zone. It is expected that the Service could make this determination within a year, provided that sufficient information is available.

Criteria 5 If the health and well-being of the experimental population should become threatened to the point that the colony's continued survival is unlikely, despite the protection given to it by the Service, State and applicable laws and regulations. An example would be if an overriding military action for national security was proposed that would threaten to devastate the colony and the removal of otters was determined to be the only viable way of preventing loss of the colony.

APPENDIX H - MANAGEMENT COSTS

Translocation costs

Personnel:		
Program Manager		**$75K**
Capture Team = $FTEs + 2 Part time Assistant		**$300K**
Transport Team	= 1 FTE + 1 Part Time Assistant	**$60**
Monitoring Team	= 2FTEs	**$90K**
Veterinary Services (Contract)		**$10K**
Law Enforcement Assistance (60 Days)		**$40K**
Transportation:		
Vans (one year lease)		**$12K**
1 Towing vehicle (one year lease)		**$6K**
1 Monitoring Vehicle (car, one year lease)		**$6K**
Air Charters for otter transport (from the islands only, 22 trips		**$20K**
Boat Charters for capture operations (26 weeks)		**$104K**
Per Diem and Travel Costs for Personnel		**$50K**
Equipment:		
Maintenance of Boats and Fuel Costs		**$25K**
Maintenance of sea otter capture equipment incl. Dive gear		**$25K**
Sea otter tracking equipment (radio flipper tags)		**$20K**
Training for Personnel		**$12K**
Research		
Blood analysis for genetic damage and environmental contaminants*		**$70K**
Tracking of sea otters to determine dispersal patterns**		**$60K**
Total estimated cost per year		**$985K**

***** Estimated cost may be reduced if less capture effort is made or alternative vessel support and/or air transport is arranged

** Costs for these activities are considered optional

APPENDIX I - DATA, CALCULATIONS, AND CONTACT INFORMATION

The tourism data set and the final calculations of costs and benefits include fairly large, complex tables and matrices that do not transfer well into a paper document. Therefore, the files have been archived on the World Wide Web in order to provide access to and use of this information to anyone who might be interested in it. To access these files please visit the Sea Otter Analysis Group's website at: http://www.bren.ucsb.edu/research/Group_Projects/2001Group_Projects/otters/Public/Default.html. This website also contains contact information for the authors of this document in case you have any questions or comments regarding this report.