Sea Otter Impacts on Commercial Fisheries in Southeast Alaska

Prepared for:

Southeast Alaska Regional Dive Fisheries Association

McDowell GROUP

Research-Based Consulting

Juneau
Anchorage

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Executive Summary

Purpose

The purpose of this report is to estimate the economic loss to Southeast Alaska commercial fisheries due to growing sea otter predation. The sea cucumber, geoduck, red sea urchin, and Dungeness crab fisheries are examined. This current document is an update of a similar economic loss assessment conducted by McDowell Group at the end of 2005. The 2005 study was, in turn, based on estimated loss of commercial species volume and ex-vessel value calculated by the Alaska Department of Fish and Game (ADFG). This current study uses similar methodology utilizing data collected by ADFG.

Methodology

Economic loss estimates in this report are based on scientific biomass data generated by subdistrict bottom surveys conducted by ADFG biologists and divers. Every dive fishery area is surveyed by ADFG divers on a rotational basis in transects prior to commercial openings in order to calculate biomass and generate Guideline Harvest Limits (GHL) for each fishery. Staff (primarily biologists) then note fishery areas which display physical evidence of sea otter predation and areas where sea otters are active.

McDowell Group has consulted extensively with ADFG staff and employed the same methods to calculate the estimated loss due to sea otter predation in the sea cucumber, geoduck, and red sea urchin fishery. In the Dungeness crab fishery, areas with high otter populations were compared to those with fewer otters to estimate the volume lost due to sea otter predation. Methodology is described in detail in this report body.

Summary of Study Findings

Economic Impacts of Sea Otter Predation on Commercial Species

- Sea otter predation in the red sea cucumber, geoduck clam, red sea urchin, and Dungeness crab fisheries is estimated to have cost the Southeast Alaska economy $28.3 million in direct, indirect, and induced impacts since 1995.

Economic Impacts of Sea Otter Predation on Southeast Alaska Commercial Fisheries

Fishery	Estimated Pounds Lost due to Sea Otter Predation	Estimated Ex-Vessel Value Lost Due to Sea Otter Predation	Estimated Wholesale Value Lost Due to Sea Otter Predation	Time Period
Sea Cucumbers	3,254,000	$5,294,000	$8,951,000	1996-2011
Geoducks	530,500	3,237,000	4,210,000	2005-2011
Red Sea Urchins	3,102,000	1,024,000	3,972,000	1995-2005
Dungeness Crab	2,681,000	3,317,000	5,301,000	2000-2010
Total	**9,567,500**	**$12,872,000**	**$22,434,000**	-

Source: ADFG data and McDowell Group estimates.

- Since 1995, it is estimated $22.4 million in wholesale value has been lost due to sea otter predation. The secondary (multiplier) impact of these losses on the regional economy is estimated to be an additional $5.8 million, for a total of $28.2 million.

- Dive fisheries and Dungeness crab fisheries in Southeast Alaska had a first wholesale value of $25 million in 2010, employing roughly 625 fishermen as well as processing workers and tender operators. The secondary economic activity resulting from these fisheries is estimated to be $6.5 million or equivalent to 59 full-time jobs.

Sea Cucumbers

- Since 1995, the sea cucumber fishery has lost an estimated 3.3 million pounds worth $9.0 million in wholesale terms, and $5.3 million in ex-vessel terms, due to sea otter predation.

- Sea otter impacts were particularly harmful in 2011, as an estimated 235,000 pounds was lost due to predation worth $2.23 million in wholesale value.

- As a result of sea otter predation, the average commercial diver harvesting sea cucumbers in 2011 lost an estimated $7,000 in ex-vessel value.

- Since 1992, ADFG has closed seven areas either specifically due to sea otter predation or presumably due to sea otter predation. Sea otters have been noted to be negatively affecting 12 other harvest areas. See Appendix 2 for a complete list and map of fishery areas affected by sea otter predation.

Geoduck Clams

- Since 2005, the geoduck clam fishery has lost an estimated 530,500 pounds worth $4.2 million in wholesale terms, and $3.2 million in ex-vessel terms, due to sea otter predation.

- Impacts were particularly costly in 2011, as an estimated 140,900 pounds were lost due to predation worth $2.0 million in wholesale value.

- As a result of sea otter predation, the average commercial diver harvesting geoducks in 2011 lost an estimated $20,000 in ex-vessel value.

- No geoduck harvest areas have yet been closed due to sea otter predation, but ADFG has identified 27 fishery areas with evidence of sea otter predation. About 70 percent of the commercial geoduck harvest comes from these 27 fishery areas, where surveys note large craters and shell fragments left over from sea otter predation.

- Although no areas have yet been closed due to sea otter predation, some prospective fishery areas found by commercial divers with sizable geoduck populations were never proposed to ADFG and therefore never opened. Sea otter predation in the area made it likely the fishery would not be worth surveying and managing by the time it could be opened (Doherty 2011, personal communication).

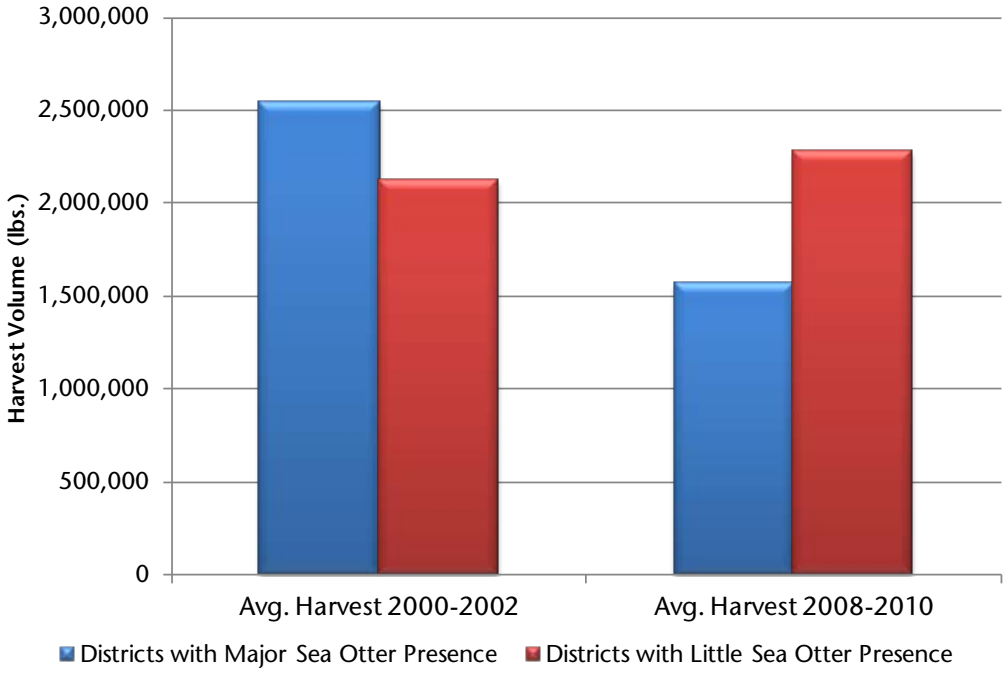
Red Sea Urchin

- The harvest of red sea urchins has declined substantially since 2006. Industry sources indicate only one or two divers are harvesting urchins in 2011, with only one active buyer. Sea otter predation impacts since 2005 have not been compiled, due to the decline of the fishery and the confidential nature of most data associated with it.
- The decline of the red sea urchin fishery in recent years is related to market factors and not due to sea otter predation.
- Prior to 2006, an estimated 3.1 million pounds of sea urchin harvest was lost due to sea otter predation, worth $4.0 million in wholesale value.
- Despite declining effort in the sea urchin fishery, sea otter predation continues to negatively impact stocks. The 2011/12 red sea urchin GHL is 3.28 million pounds, a 40 percent decline from the 2008/09 GHL of 5.44 million pounds. If the market value rebounds and fishery participation increases, the lost GHL due to sea otters will be realized in future years as GHL's are expected to decline.

Dungeness Crab

- Sea otters regularly eat Dungeness crab, which are an attractive food source given their abundance in Southeast Alaska, considerable size, and relative ease of capture.

Comparison of Southeast Alaska Dungeness Crab Harvest in Districts with Major Vs. Minor Sea Otter Presence



Note: Districts with major sea otter presence include districts: 3, 5, 6, 9, 10, and 13.
Source: ADFG harvest data.

- The three-year average harvest from districts with significant sea otter presence was 975,000 pounds less in 2008 through 2010, compared to the 2000-2002 period, a decline of 38 percent. In comparison, districts with less sea otter presence saw average harvests increase 151,000 pounds between the two periods, an increase of 7 percent.

- The Southeast Alaska Dungeness crab fishery has lost an estimated 2.7 million pounds of commercial harvest due to sea otter predation since 2000, worth $3.3 million in ex-vessel terms and $5.3 million in wholesale value.

Sea Otter Population Growth

According to available data, the Southeast Alaska sea otter population has increased significantly, particularly in southern Southeast Alaska where the region's dive fisheries occur. The most recent population survey was completed in 2002 and 2003, indicating a Southeast Alaska population estimate of 8,949 animals. More recent studies suggest annual growth rates are 12 percent in southern Southeast Alaska and 4 percent in northern Southeast Alaska (Hoyt 2011, personal communication). Other authoritative literature suggests sea otter populations can grow at an annual rate of 20 percent per year when expanding into new territory (Paul 2009).

The Southeast Alaska sea otter population is projected to be approximately 19,000 in 2011, increasing from less than 9,000 animals in the most recent published population estimate. By 2015, the Southeast population is expected to approach 28,000 animals. These estimates incorporate the subsistence harvest of sea otters by Alaska Natives.

Estimated Southeast Alaska Sea Otter Population, 2002 - 2015

Season	Last Population Survey (2002/2003)	Projected 2011 Population	Projected 2015 Population	Survey Coefficient of Variation (CV%)
Southern Southeast				
12% Annual Growth Rate	5,845[1]	14,472	22,772	0.14
Northern Southeast (including Glacier Bay)				
4% Annual Growth Rate	3,104[2]	4,418	5,168	0.16
Total Southeast Alaska				
Estimated Population	**8,949**	**18,890**	**27,940**	-

[1]Population estimate is from 2003.
[2]Population estimate is from 2002.
Source: U.S. Fish and Wildlife Service, Hoyt 2011 (personal communication), and McDowell Group calculations.

Given current foraging research, a conservative estimate about body weight (50 lbs.) and daily food intake (20 percent of body weight); a sea otter population of 27,940 would consume just over 10 million pounds of commercial species per year in Southeast Alaska. The entire 2010 Southeast Alaska harvest in the dive and Dungeness crab fisheries was 5.9 million pounds.

Abalone

A commercial fishery for northern abalone (*Haliotis kamtschatkana*) existed in Southeast Alaska from the late 1970s to mid 1990s. Guideline harvest levels where not applied until the 1980/81 season and the fishery slowing declined thereafter. Similar collapses occurred in British Columbia and Washington state.

The fishery collapsed almost certainly because of excessive harvests in the late 1970s and early 1980s. There was not a sufficient stock assessment or research program in place when the Alaska fishery boomed and there was insufficient support to develop a program within the department. Further, there was inadequate understanding among the global research community of the special vulnerabilities of abalone populations to overharvest (ADFG Report to Alaska Board of Fisheries 1999).

The decline of the abalone is probably a long-term condition now that sea otters have expanded to occupy much of their former range. Otter populations have grown exponentially since their reintroduction into outer coastal waters of southeast Alaska in the 1960s, and there are only a few pockets of abalone habitat that have not yet seen a resurgence of otters. The two species share the same environment. Otters are uniquely adapted to prey on abalone and it is clear that abalone cannot co-exist in commercial quantities with sea otters (ADFG Report to Alaska Board of Fisheries 1999).

The decline of the abalone fishery, like the decline of the red sea urchin fishery, was not related to sea otter predation. However, given current otter populations and population growth rates, it is virtually impossible that these species will abound in commercial quantities in the future. By limiting the abalone's population from fully rebuilding - enough to support a commercial fishery - sea otters have diminished the future value of Southeast Alaska's commercial dive fisheries.

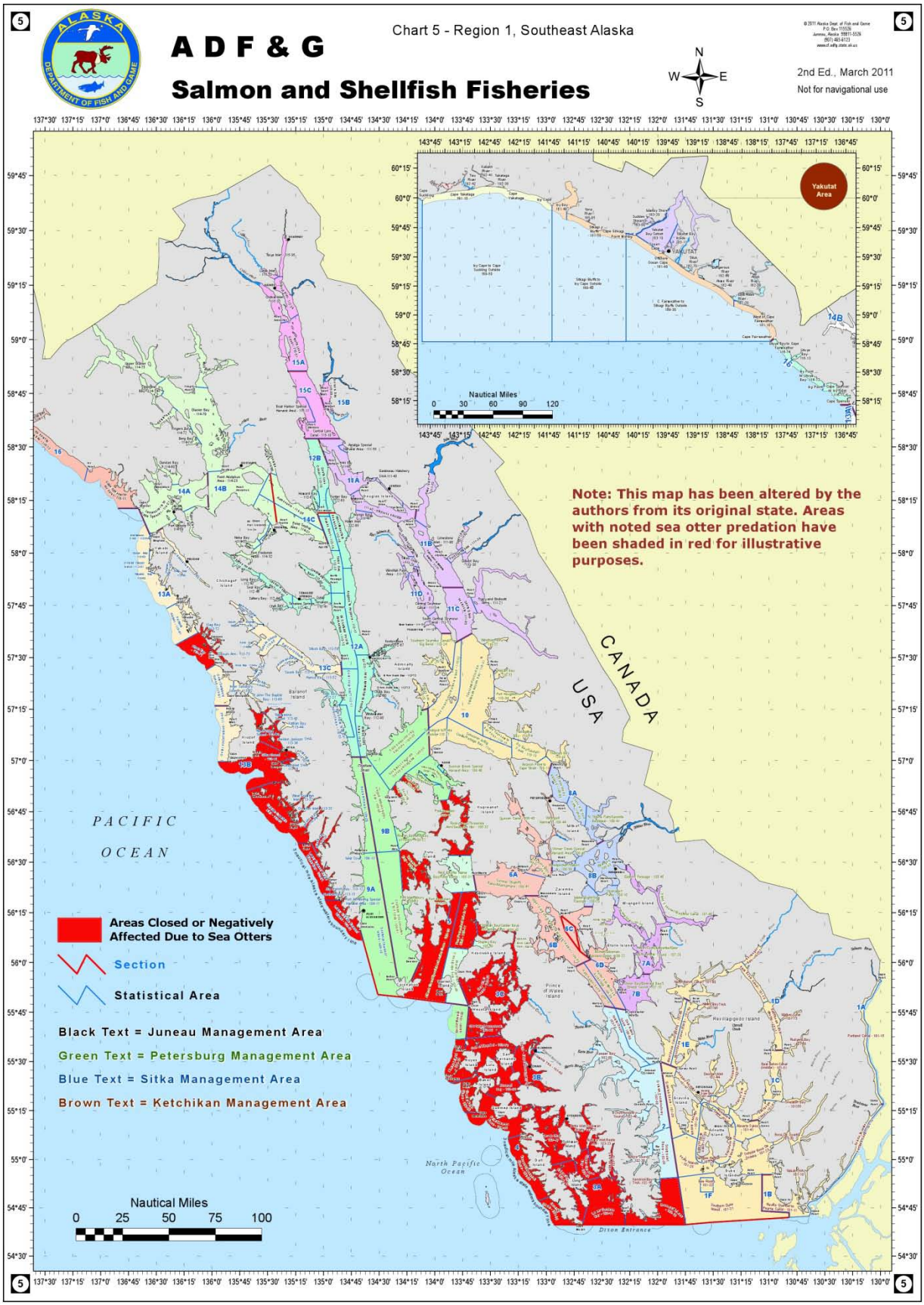
Observations of Sea Otter Predation on Commercial Species

ADFG field research and industry divers support the notion that sea otters are having a significant negative impact on the harvest volumes of geoduck, urchins, crab and other marine species. Growing sea otter populations have led to the depletion of many of these resources within the otters' range, closing some fisheries and leaving others economically unfeasible. In recent years, ADFG has closed 17 dive fishery harvest areas due to sea otter predation.

Given the food source which developed during the last 100 years with little otter predation, it is expected the outer coastline will eventually become continuously populated with sea otters from Dixon Entrance to well north of Cape Spencer (Pritchett and Hoyt, 2008). In addition, many commercial fishermen have noted otter populations in inside waters, expanding their range beyond the coastal areas.

This report contains estimates of financial losses incurred by commercial divers in the past and present, due to sea otter predation. However, large sea otter populations inevitably threaten the future of dive fisheries and crab fisheries; jeopardizing hundreds of jobs and tens of millions of dollars in economic activity for the region.

Map of Fishery Areas Negatively Affected by Sea Otters



Introduction

Purpose of the Research

The commercial harvest closures have resulted in measurable economic impacts on the seafood sector and on communities in Southeast Alaska. Harvesters, processors, and seafood-dependent communities experience lost employment, wages, tax revenue, and related economic activity. The Southeast Alaska Regional Dive Fisheries Association (SARDFA) contracted with McDowell Group to quantify and explain these impacts in 2005. Since the 2005 report, otter populations have continued to grow, further impacting dive fisheries and crab fisheries. This report uses current ADFG data and sea otter research to update the impacts of sea otter predation on Southeast Alaska fisheries and communities.

Methodology

In 2005, the Alaska Department of Fish and Game (ADFG) estimated the lost guideline harvest level (GHL) due to sea otter predation in the red sea urchin and sea cucumber fisheries. These estimates were contained in a November 2005 memorandum. McDowell Group consulted with ADFG biologists who survey the fishery and calculated the original estimates of lost GHL. Using new ADFG biological survey data regarding biomass and sea otter predation, McDowell Group has employed the same methods as those used in 2005 to update the estimates of economic loss.

The Alaska Department of Fish and Game provided McDowell Group with publicly available biomass survey data and professional input (based on survey experiences and institutional knowledge). The scientific survey data and interviews with expert professionals in the department are used in this report. In addition, prior to release of this report, ADFG professionals reviewed the report to ensure data and information provided by ADFG is objectively and accurately represented.

It is important to note, however, ADFG has not conducted controlled experiments to examine the effects of sea otter predation on invertebrate populations. Their estimates are based on regular, direct observations made during dive surveys and the department's expertise as fishery managers.

Estimates of lost harvest volume were combined with average ex-vessel price data from ADFG to estimate the lost value in ex-vessel earnings. Wholesale values are based on data from the ADFG Commercial Operators Annual Report (COAR) database.

Wholesale value impacts are inclusive of impacts reflected by the loss of ex-vessel value. This is because wholesale value of a product, or the revenues a processing company gains through sale of the product, must pay for the expenses incurred in the procurement and processing of that product. This includes the purchase of the raw material from harvesters, which is reflected as the ex-vessel value.

Species Profile and Diet

Sea otters (*Enhdyra lutris*) are a member of the weasel family and a significant predator in the ecosystems of much of coastal Alaska, from Southeast to the Aleutian Islands. Their average life span is 15 to 20 years. Adult male otters weigh typically weight 70 to 90 pounds and average about 4.5 feet in length, while females average 40 to 60 pounds.

The sea otters' only natural predators are sharks, killer whales (orcas), and bald eagles. Sharks and killer whales are not particularly plentiful in Southeast Alaska, and there is no shortage of other food sources for these predators. There is a very narrow window for bald eagles to hunt sea otter pups. Relatively soon after being born, the pups are able to dive and evade the eagles.

Sea otters are the only marine mammal without blubber. As a result, the animals have a high metabolism and require large amounts of food to survive. Sea otters in captivity will consume up to 25 percent of the body weight per day.[1] One male otter, therefore, can consume up to 7,300 pounds of food in one year.

Instead of blubber, sea otters have a dense, water resistant coat which traps air close to their body insulating them from the frigid waters of the North Pacific. Sea otters have the densest coat of any mammal, with roughly a million hair follicles per square inch. By comparison, the human scalp has only 20,000 hairs in total.

Sea otters typically forage in depths of 9 to 27 feet; however, a dive of 291 feet was recorded by an animal which drowned while attempting to remove bait from a crab pot.

Many studies have been conducted on the foraging habits of sea otters. Aside from the tremendous volume of food needed to sustain otters, researchers found significant differences in foraging habits depending on location and available prey. Antonelis et al. (1981) and Ostfeld (1982) found evidence to confirm the hypothesis that otters choose prey with the highest ratio of caloric-value to energy expended foraging (Barnes 2002).

Other studies tend to support the notion that sea otters are opportunistic generalists which adapt their predation to their environment. Studies from the Aleutian chain to Prince William Sound to Southeast Alaska have found different foraging habits. The most recent study, (Hoyt 2010), is collecting foraging data on sea otters in southern Southeast Alaska. Preliminary data from this study suggests when sea otters move into new areas they

[1] U.S. Fish and Wildlife Service. "Wildlife Biologue – Northern sea otter in Alaska (*Enhydra lutris kenyoni*)." p2.

are more likely to prey on commercials species. Over all, that study suggests commercial species make up 10 percent of the sea otter diet in southern Southeast Alaska.

Historical Population

Sea otters were completely removed from their natural range in Southeast Alaska by intense pressure from fur traders in the 18th and 19th centuries. Prior to the fur trade period sea otter populations in the entire North Pacific Rim – extending from Japan to Alaska to Baja California – ranged from 200,000 to 300,000 (Hoyt 2010). Sea otters were believed to have been eliminated from Southeast before 1900 (Pitcher 1989). In 1911, an international treaty, the North Pacific Fur Seal Convention, passed protecting sea otter populations in the United States, Russia, and Japan from further intensive exploitation.

The reintroduction of the sea otter into the Southeast region occurred from 1965 to 1969. A total of 402 animals were relocated from the Aleutian Islands and from Prince William Sound. Otter relocation sites included Khaz Bay, Yakobi Island, Biorka Island, the Barrier Islands, the Maurelle Islands, and Cape Spencer. The Southeast Alaska sea otter population remained low until 1987 when it began a period of rapid growth (Pitcher and Imamura, 1990).

Since that time, sea otter populations have been increasing, and the range of the animals has expanded and shifted correspondingly. The most recently completed population survey, conducted in 2002 and 2003, estimated the Southeast sea otter population at 8,949 animals. Based on aerial surveys performed in 2010 southern Southeast Alaska sea otter populations are believed to be growing at 12 percent per year. Sea otter populations in northern Southeast and Glacier Bay are believed to be growing at 4 percent (Hoyt 2011, personal communication).

Estimated Southeast Alaska Sea Otter Population, 2002 - 2015

Season	Last Population Survey (2002/2003)	Projected 2011 Population	Projected 2015 Population	Coefficient of Variation (CV%)
Southern Southeast				
12% Annual Growth Rate	5,845[1]	14,472	22,772	0.14
Northern Southeast				
4% Annual Growth Rate	1,838[2]	2,616	3,060	0.17
Glacier Bay				
4% Annual Growth Rate	1,266[2]	1,802	2,108	0.15
Total Southeast Alaska	**8,949**	**18,890**	**27,940**	-

[1]Population estimate is from 2003.
[2]Population estimate is from 2002.
Source: U.S. Fish and Wildlife Service, Hoyt 2011 (personal communication), and McDowell Group calculations.

Based on 2003 survey work, and a 12 percent annual growth rate, the current sea otter population of southern Southeast is believed to contain about 14,500 animals. By 2015, the southern Southeast population is expected to exceed 22,700 animals.

With a large food source available, high population growth rates will likely persist for some time. By 2015, the Southeast Alaska sea otter population is conservatively projected to contain 27,940 sea otters. Given current foraging research and a conservative estimate about body weight (50 lbs.) and daily food intake (20 percent of body weight), a sea otter population of 27,940 would consume just over 10 million pounds of commercial species per year in Southeast Alaska. The entire 2010 Southeast Alaska harvest in the dive fisheries and Dungeness crab fisheries was 5.9 million pounds. Southeast Alaska sea otters consumed an estimated 6.9 million pounds of commercial species in 2011.

Population growth rates may actually increase if otters migrate further outside of their current territory. Sea otter populations can grow by 20 percent per year when colonizing new areas with sufficient food sources and few predators (Watson 2000). From 1975 to 1987, the growth rate of the sea otter population in southeast Alaska was estimated at 17.6 percent per year (Estes 1990).

Population growth rates are limited primarily by three factors: abundance of food, predators, and population size. As a population grows larger, it consumes more resources and mortality rates increase. The fact that sea otter populations are growing three times faster in southern Southeast, despite a population which is three times larger would indicate a substantial food source available to the southern Southeast otters. One of the key differences between northern and southern Southeast, as they relate to sea otters, is the presence of large macroinvertebrate populations in the southern region.

Updated sea otter population figures will be forthcoming. The U.S. Fish and Wildlife Service (USFWS) performed aerial surveys during the summer of 2010 and 2011, but has not yet released their findings.

Recent Sea Otter Research in Southern Southeast Alaska

The most direct observation of sea otter effects on commercial fisheries comes from dive surveys performed by ADFG biologists and an ongoing North Pacific Research Board project headed up by researchers from the USFWS and the University of Alaska – Fairbanks (UAF).

ADFG performs annual dive surveys on areas open to commercial dive fisheries. Divers survey the near-shore seabed in pairs for sea cucumbers, geoducks, and sea urchins covering 2-meter-wide transects. Sea otter presence is noted during these surveys.

Observations made by ADFG divers on the outer coast of Southeast Alaska suggest sea otters select red sea urchins and pinto abalone when foraging on rock habitat and on several species of clams including geoduck clams when foraging on soft sand and mud substrate. Once these species have been depleted it appears they turn to less desirable prey such as sea cucumbers and snails (Walker, Pritchett and Hoyt, 2006).

A collaboration of researchers and specialists from UAF and USFWS embarked on a four-year project beginning in July 2010 to study interactions between sea otters and commercially important prey in southern Southeast Alaska. The project will also survey sea otter populations and study movement, habitat, and diets of otters in Southern Southeast Alaska. Preliminary results from this project have revealed the following:

- Otters can consume up to 23 percent of their body weight in a day, as they have a very high metabolic rate.

- Distribution of sea otter populations have grown and moved further inland from outer coastal areas.
- Preliminary foraging data suggests commercially important species make up 10 percent of sea otters' diet. (However, this data was collected from areas with relatively small populations of commercial dive species, and other studies have noted different foraging behavior in different regions).
- When sea otters initially colonize an area, they consume larger amounts of commercially important species such as sea cucumbers and Dungeness crab.

POTENTIAL CONSEQUENCES FOR SEA OTTERS AND COMMERCIAL FISHERIES

The sea otter population will likely continue to expand rapidly in coming years as otters consume the large biomasses of crab and macro invertebrate, species which built up in the absence of sea otters during the past century. When these biomasses have been depleted otters will need to find other food sources and many may die off due to starvation. However, because sea otters are opportunistic generalists, it is likely commercial dive fisheries and Dungeness crab fisheries in Southeast Alaska may never return to biomass levels that allow sustainable commercial harvests.

The natural balance between sea otters and their prey, which existed before fur traders wiped out sea otters in Southeast Alaska, did not allow for an imbalance between sea otters, crabs, and macro invertebrates. The population of one group either limited or fueled growth in the other. In such a situation, large-scale commercial dive fisheries and Dungeness crab fisheries may not be possible because crab and macro invertebrate populations would not be able to reach a size large enough to support a fishery of current proportions (given unabated sea otter predation).

In short, commercial dive fishing and large populations of sea otters cannot coexist in the same waters. In addition, once the commercially viable biomass of crab and macro invertebrates – such as sea cucumbers and geoducks - is gone, it likely will not return given sustained sea otter predation.

Southeast Alaska Dive Fisheries

Southeast Alaska dive fisheries occur primarily during the fall and harvest three species of bottom-dwelling marine invertebrates: geoduck clams (*Panopea generosa)*, California sea cucumbers (*Parastichopus californicus)*, and red sea urchins (*Strongylocentrotus franciscanus)*. All three fisheries occur primarily in southern Southeast Alaska waters. Entry into the fishery is limited, but those who hold permits compete to harvest commercial species within the limits of guideline harvest levels established by ADFG.

Alaska dive fisheries started to develop in the mid-1960s, with a fishery for pinto abalone. In the 1980s commercial dive fisheries developed for sea cucumbers, sea urchins, and geoducks. In 2000, the Alaska Commercial Fisheries Entry Commission (CFEC) limited access to the fishery, restricting further growth in the number of participants.

In 2010, Southeast Alaska dive fisheries produced a first wholesale value of $16.7 million and paid out $9.4 million to divers. Roughly 180 permitted divers participated in the fishery in 2010 for average earnings of $52,100 per diver. This revenue is shared with crew, as the average commercial diver employs 0.8 crew members according to surveys done by the Alaska Department of Labor and Workforce Development.

Impacts to the Southeast dive fisheries extend beyond payments made to divers. The fisheries occur during the fall, after the busy summer season when harvests of salmon, halibut, black cod, and herring are finished (or nearly finished). Dive fishery harvests provide processors with additional revenue and the ability to extend some seasonal processing jobs by allowing some processing staff to handle dive fisheries production. In addition, the fisheries add to the state, local, and federal tax base and create business for local dive shops, transport companies, and other related businesses.

Geoduck Clams

Geoduck clams command the highest price of the three dive species. Virtually all Alaska geoducks are exported to China and in 2010 geoduck clams sold for an average wholesale price of $8.72 per pound. Quality geoducks, in the proper retail market, can command prices upwards of $20 per pound.

Southeast Alaska Geoduck Clam Dive Fishery Snapshot

	2010/11 Season	Pct. Change Since 2005/06
Number of Active Divers	69	-3%
Average Permit Value	$81,600	+93%
Total Harvest (in lbs.)	887,500	+39%
Total Ex-Vessel Value	$5.9 million	+197%
Average Ex-Vessel Price	$6.67	+114%
Total First Wholesale Value	$8.0 million	+186%
Average First Wholesale Price (per processed lb.)	$8.72	+94%
Average Revenue Generated Per Diver	$115,900	+195%

Source: ADFG.

Geoduck fisheries take place throughout southern Southeast Alaska, and in waters surrounding Baranof Island. A total of 69 divers fished in 2010, although there were 91 permits for the fishery. The fishery had an ex-vessel value of $5.9 million in 2010, and a wholesale value of $8.0 million.

The value of the fishery has increased in recent years, as prices and harvest volumes have both risen. Harvest volume has grown in spite of sea otter predation because new harvest areas were discovered and added to the fishery. However the 2011/12 quota is only 557,900 pounds – the lowest since 2003 when there were fewer harvest areas. Further harvest reductions are likely because most of the region has been surveyed and areas with commercial quantities have already been opened. So as established areas lose GHL to otter predation, new areas are not expected to make up for the shortfall as they have in the past.

During the past several years, SARDFA surveyors have found substantial geoduck clam beds but in some instances did not attempt to open these areas because sea otters where active in the vicinity. By the time the areas could be surveyed, studied, and opened (at a cost ultimately borne by the industry) the beds would most likely be depleted below a commercially viable level.

Sea Cucumbers

Sea cucumbers are also sold primarily into Chinese markets. Sea cucumbers are raised in large numbers in China in artificial ponds and man-made tide pools. Wild Alaska sea cucumbers tend to be much larger and have higher nutritional value, therefore command a premium price in the Chinese market.

Southeast Alaska Sea Cucumber Dive Fishery Snapshot

	2010/11 Season	Pct. Change Since 2005/06
Number of Active Divers	180	-9%
Average Permit Value	$11,300	+27%
Total Harvest (in lbs.)	1.27 million	-12%
Total Ex-Vessel Value	$3.4 million	-
Average Ex-Vessel Price	$2.65	+16%
Total First Wholesale Value (per processed lb.)	$8.1 million	+60%
Average First Wholesale Price	$10.88	+45%
Average Revenue Generated Per Diver	$45,000	+75%

Source: ADFG.

A total of 180 divers fished in 2010, although there were 291 permits for the fishery. Alaska sea cucumbers had an ex-vessel value of $3.4 million in 2010, and a wholesale value of $8.1 million.

The fishery's value has increased substantially in recent years due to rising prices. Because areas are only harvested once every three years, the harvest can fluctuate greatly from year to year. Despite the fluctuations due to harvest area rotation, the 2011/12 quota is very low. The 2011/12 quota of 999,000 pounds is the lowest since the late 1990s.

Red Sea Urchins

Red Sea Urchins are harvested for their gonads, which is a delicacy in Japan. Male and female sea urchin gonads, both known as *uni* in Japanese, are served in sashimi or in sushi.

Participation in the urchin fishery has declined since 2000, although 2010 posted the first increase in participation since 2004. Still, only 12 divers fished in 2010, out of 71 permits. The fishery had an ex-vessel value of $148,000 in 2010. The average gross earnings of $12,300 per diver in 2010 is the lowest since access to the fishery was limited in 2000. An industry source reports only "one or two" divers are participating in the 2011/2012 fishery, with only one buyer.

Economic Impacts of Sea Otter Predation

As sea otter populations have recovered in areas of the Pacific Coast, conflict has arisen with commercial and subsistence fisheries. Sea otters prey on sea urchins, Dungeness crab, shrimp, clams, abalone, sea cucumbers, and geoducks, among other animals. There are multiple studies that note sea otter population growth can have a negative effect on commercial stocks of these species, potentially resulting in the closure or drastic reduction of the commercial fishery. In one such example, Watson and Smith, in their 1996 paper examining sea otter/fishery interactions in British Columbia, noted there is "no doubt that sea otters threaten urchin fisheries."

Indeed, as sea otters have reestablished themselves in various areas of Southeast Alaska, formerly abundant stocks of several invertebrate species have been locally depleted below commercially harvestable levels. Since 1993 the Alaska Department of Fish and Game has closed 17 dive fishery harvest areas due to presumed sea otter predation. The Department estimates sea otter predation affects 39 percent of Southeast dive fishery harvest areas.

Summary of Dive Fishery Areas Affected by Sea Otter Predation

Species	Total Harvest Areas	Areas Closed Due to Sea Otters	Areas Closed, Presumably Because of Sea Otters	Areas Affected by Sea Otters but Not Closed	Percentage of Areas Affected or Closed Due to Sea Otters
Geoducks	41	0	0	27	66%
Sea Cucumbers	67	3	4	12	28%
Red Sea Urchins	59	4	6	9	32%
Total	**167**	**7**	**10**	**48**	**39%**

Source: ADFG.

The financial impact of sea otter predation affects commercial divers, processors, dive shop owners, and communities both inside and outside of Alaska. This section focuses on the cost of sea otter predation to divers and processors, who have lost revenue in the form of ex-vessel earnings and wholesale revenues due to sea otters.

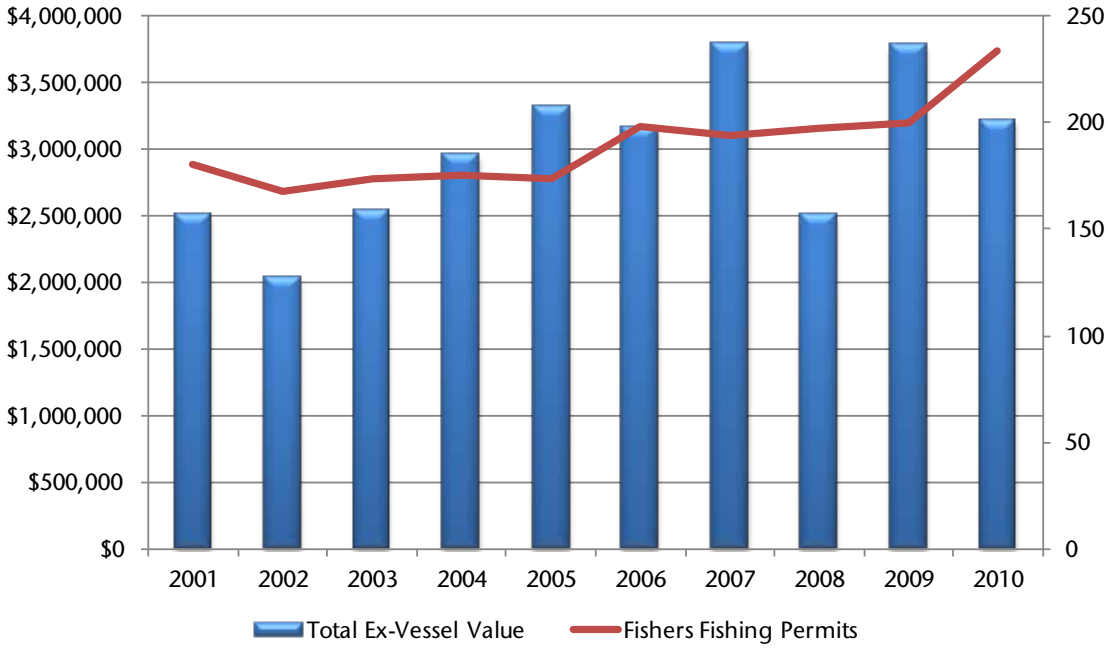
Sea otter predation has had obvious and measureable economic impacts on the sea cucumber, red sea urchin, geoduck, and Dungeness crab fisheries of Southeast Alaska. This report quantifies the estimated impacts sea otters have had on these species. In addition, sea otters affect the tanner and king crab fisheries of Southeast Alaska; however, data to quantify these impacts on these fisheries is not yet available.

Sea Cucumbers

Historical Harvest and Value

Sea cucumber fisheries occur throughout much of Southeast Alaska, in waters surrounding Prince of Wales Island, including Clarence Strait, east to the Behm Canal and waters around Revillagigedo, Gravina, and Annette Islands, and south. Fisheries also occur around Sitka, and in Sumner and Chatham Straits. Each subdistrict opens once every three years. Although divers are allowed to harvest sea cucumbers from October through March of the following year, virtually 100 percent of the harvest occurs during October and November. So although the 2011/12 season will run through March 31, 2012, most of the GHL has already been harvested.

Sea Cucumber Ex-Vessel Value and Participation
2001 - 2010



Source: CFEC.

In 2000, the Commercial Fisheries Entry Commission limited access to the fishery. Since limited access to the fishery, participation has ranged from a peak of 234 permits fished in 2001 to a low of 168 permits fished in 2009. A total of 180 permits were fished in 2010, and fishermen earned a total of $3.2 million or $17,850 per diver.

From 2007 to 2010, ex-vessel prices ranged from $2.86 to $2.56 per pound, but prices are much higher in 2011. Reports from the grounds indicate divers are being paid $5.50/lb. for sea cucumbers this season. While the price appreciation is certainly a positive for fishermen, total ex-vessel values may not increase as much because the guideline harvest level for the 2011/12 season is down. Fishermen will be allowed to harvest roughly 1 million pounds of sea cucumber this season, a 12 percent decline from the 2008/09 season - the last time these this group of subdistricts was harvested.

Impacts of Sea Otters on Southeast Alaska Sea Cucumber Fishery

Sea otters are opportunistic generalists, consuming a wide variety of near-shore prey. Data collected in 2010 on the foraging habits of sea otters near Kake, Alaska revealed sea cucumbers made up 3.1 percent of the sea otters' diet. Similar foraging observations were made in Southwest Alaska during a 2003 study.

Although sea cucumbers do not represent the majority of sea otters diet, otters do consume large amounts of sea cucumbers each year which has had an adverse of effect on the sea cucumber fishery.

Since 1996, sea otter predation has resulted in an estimated lost GHL of 3.25 million pounds worth $5.3 million in ex-vessel terms and $8.4 million in wholesale markets.

In 2011, sea otter predation led to a loss of roughly $7,000 for every active sea cucumber diver.

Estimated Sea Cucumber GHL and Value Lost Due to Sea Otters, 1996/97 – 2011/12

Season	GHL Lost Due to Sea Otters	Ex-Vessel Price ($)	Estimated Ex-Vessel Value Lost Due to Sea Otters	First Wholesale Value/lb. (round weight basis)	Estimated Wholesale Value Lost Due to Sea Otters
2011/12*	235,000	$5.50	$1,293,000	$9.50	$2,231,000
2010/11	151,000	$2.65	400,000	$6.37	961,000
2009/10	192,000	$2.59	497,000	$3.78	725,000
2008/09	241,000	$2.56	617,000	$3.94	949,000
2007/08	116,000	$2.86	332,000	$4.40	511,000
2006/07	143,000	$1.99	285,000	$3.35	480,000
2005/06	184,000	$2.29	421,000	$3.45	634,000
2004/05	140,000	$2.12	297,000	$3.48	488,000
2003/04	150,000	$1.47	213,000	$3.48	522,000
2002/03	84,000	$1.26	106,000	$2.51	211,000
2001/02	100,000	$1.75	175,000	$2.43	243,000
2000/01	130,000	$2.23	290,000	$2.41	313,000
1999/00	59,000	$1.94	115,000	$2.91	172,000
1998/99	40,000	$1.55	62,000	$3.09	124,000
1997/98	90,000	$1.66	147,000	$3.37	304,000
1996/97	34,000	$1.28	44,000	$2.44	83,000
Total	**3,254,000**	-	**$5,294,000**	-	**$8,951,000**

* 2011/12 data is preliminary and based on prices reported by industry.
Source: ADFG data and McDowell Group estimates.

Sea otter predation has forced closures, been observed, or affected 19 sea cucumber harvest areas out of a total of 67 harvest areas. Since 1993, ADF&G has closed three harvest areas specifically due to sea otter predation and has noted four additional areas were probably closed due to sea otters. Two new harvest areas were closed in 2011, specifically due to sea otters.

Geoducks

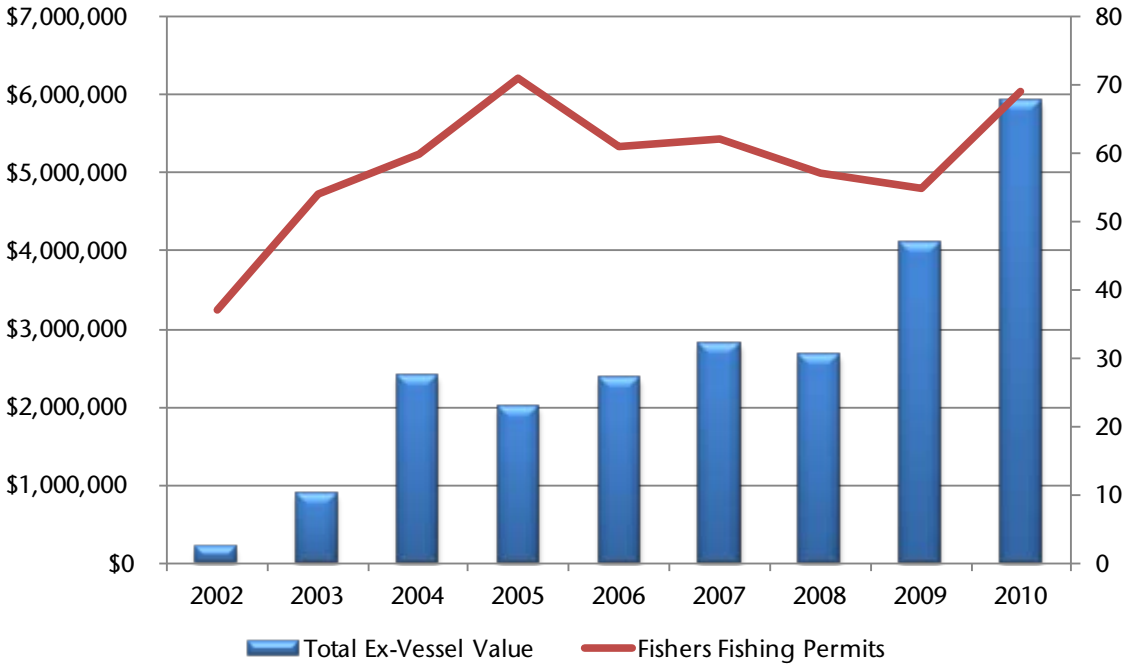
Historical Harvest and Value

Currently there are 39 commercial geoduck clam harvest areas in Southeast Alaska and 2 control areas not open for harvest. All of these areas are located in southern Southeast Alaska, with most of the GHL contained in areas surrounding the communities of Ketchikan, Craig, and Sitka.

Since 2004, and particularly in the last three years, the Southeast Alaska geoduck fishery has become a lucrative fishery. Ex-vessel prices for geoducks have nearly tripled since 2008. Reports indicate geoduck divers are receiving $10.50/lb. from processors this season (2011/12).

Geoduck prices have increased in recent years primarily because coordination between government regulators, fishery managers, and commercial divers has improved. Better communication and coordination has allowed the industry to now sell all geoduck clams as live product. Live geoduck clams command a significantly higher price.

Geoduck Ex-Vessel Value and Participation, 2002 - 2010



Source: CFEC.

Harvest volume has been relatively steady since 2004, ranging from 557,900 to 824,800 pounds. Participation in the fishery has also been steady, with 55 to 71 divers participating in the fishery. In 2010, a total of 69 divers out of 91 permit holders harvested geoducks.

Impacts of Sea Otters on Southeast Alaska Geoduck Clam Fishery

Sea otter predation has become more evident in geoduck clam fisheries since the early 2000s (Walker 2011, personal communication). With geoduck fisheries becoming more commercially important in recent years, these adverse effects have become more costly for commercial divers.

Otter predation in the geoduck fishery is especially evident. Otters dig large holes into the seabed, pull up the geoduck clam, eat the meat and discard the shells – leaving behind a large hole and shell debris which divers note in their surveys. Surveys performed in 2009 on the Portillo Channel (Subdistrict 103-50) area revealed notable otter presence in 70 of 74 transects. Surveys performed on the Lower Cordova Bay (102-10 and 103-11) area showed sea otter presence in over half that district's 60 transects (Rumble and Siddon, 2011).

McDowell Group employed the same methodology used by ADFG to estimate effects on the sea cucumber and sea urchin fisheries from 1996/97 to 2005/06 to estimate geoduck harvest volume and value lost to sea otter predation.

Evidence of sea otter predation has been observed at 27 of the 39 geoduck harvest areas. Biomass has decreased significantly in seven of these 27 areas since 2003. Given the noted sea otter activity in these geoduck fishery areas and lack of other natural predators, it is believed the declining biomass can be attributed to sea otters for these seven harvest areas.

Since 2005, sea otter predation has resulted in an estimated lost GHL of 530,500 pounds worth $3.2 million in ex-vessel terms and $4.2 million in wholesale markets. In 2011, sea otter predation was particularly costly, leading to a loss of roughly $20,000 for every active geoduck diver. This is money which is directly taken out of family budgets and local economies.

Estimated Geoduck GHL and Value Lost Due to Sea Otters
2005/06 – 2011/12

Season	GHL Lost Due to Sea Otters	Ex-Vessel Price ($)	Estimated Ex-Vessel Value Lost Due to Sea Otters	First Wholesale Value/lb. (round weight basis)	Estimated Wholesale Value Lost Due to Sea Otters
2011/12*	140,900	$10.50	$1,479,000	$13.97	$1,969,000
2010/11	43,800	$6.61	289,000	$9.03	77,000
2009/10	142,300	$5.48	780,000	$6.46	919,000
2008/09	18,700	$3.66	69,000	$5.38	101,000
2007/08	95,100	$3.50	333,000	$4.76	452,000
2006/07	10,200	$3.67	37,000	$5.00	51,000
2005/06	79,500	$3.15	251,000	$4.06	323,000
Total	**530,500**	-	**$3,237,000**	-	**$4,210,000**

* 2011/12 ADF&G data is preliminary and values are based on prices reported by industry.
Source: ADFG data and McDowell Group estimates.

Geoducks are in a precarious situation due to sea otters. While prices are high and divers are earning good money harvesting them, that could soon end.

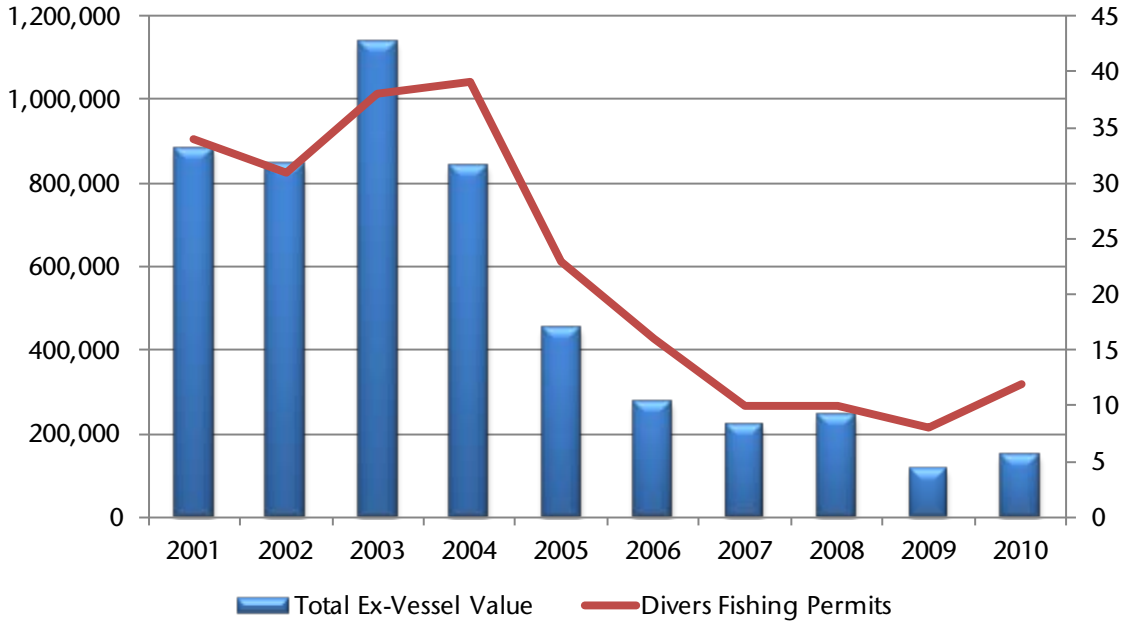
Evidence of sea otter predation has been observed at 27 geoduck fishery areas, but only seven of those areas exhibited significant biomass declines in recent years. However, if those other areas with sea otter activity become harder hit, the impact on the fishery could be devastating because sea otter predation has been noted in harvest areas containing 70 percent of the geoduck biomass. Should otters focus on geoducks as a food source more in the future, it is unlikely the geoduck biomass could reproduce quickly enough to support a commercial fishery which is economically feasible or biologically sustainable.

Red Sea Urchins

Historical Harvest and Value

Participation in the Southeast Alaska red sea urchin fishery has declined rapidly in recent years, approaching zero. During the 2011/12 season, only "one or two" are harvesting urchins with only one buyer, according to an industry source. In 2005, the fishery harvested 1.6 million pounds of red sea urchin worth an ex-vessel value of $453,000. By 2010, production dwindled to 509,000 pounds, harvested by 12 divers who shared $147,700 in total ex-vessel value. The 2010 harvest was just 10 percent of the 4.95 million pound guideline harvest level.

Red Sea Urchin Ex-Vessel Value and Participation, 2001 - 2010



Source: CFEC.

In the red sea urchin fishery, dwindling participation is not being driven by sea otter predation, but rather a falling market value for the product. The gonads of red sea urchins, called *uni* by the Japanese, are a popular sushi item. Virtually all of Alaska's urchin production gets exported to Japan. In general, other urchin fisheries in Russia and the west coast harvest enough supply for the Japanese *uni* market. In addition, there have been market issues with Alaska urchins stemming from inconsistent quality (due to biological factors) and mishandled product by shippers.

In 2000, red sea urchins were fetching $0.45/lb. on the grounds. Ex-vessel prices have steadily declined since then, and in 2010, the 12 divers who participated in the fishery were paid an average price of $0.29/lb. Meanwhile, ex-vessel prices for geoducks and sea cucumbers have risen substantially during this period, along with fuel costs and other operating costs. Low volume and the opportunity cost of harvesting urchins, when a diver could be targeting geoducks or sea cucumbers, has made the fishery uneconomical for most divers and processors.

Impact of Sea Otters on the Southeast Alaska Red Sea Urchin Fishery

In 2008, the average sea urchin diver grossed $24,000, and prior to that time divers generally averaged $20,000 to $30,000 per season. Because sea urchins are a major food source for otters, the financial impact on commercial divers was significant.

Sea otter predation resulted in an estimated harvest shortfall of 3.1 million pounds from 1996 to 2005 worth 1.0 million in ex-vessel terms and 4.0 million in wholesale value.

Estimated Red Sea Urchin GHL, Harvest and Value Lost Due to Sea Otters, 1995/96 – 2005/06

	GHL Lost Due to Sea Otters	Estimated Harvest Lost Due to Sea Otters (adjusted lbs.)	Estimated Ex-Vessel Value Lost Due to Sea Otters	Estimated Wholesale Value Lost Due to Sea Otters
Total	6,285,000	3,102,000	$1,024,000	$3,972,000

Source: ADFG data and McDowell Group estimates.

Participation in the fishery is now so low that many figures on the fishery are confidential, and since only a small portion of the GHL is harvested, the impact of sea otters in recent years is likely very small. For these reasons, sea otter impacts have not been calculated for the 2006/07 through 2011/12 seasons. However, sea otters did have a large impact on the fishery in the past, and will continue to feed on urchins in the future. In an area from the southern shoreline of Sitka Sound to West Crawfish Inlet it was estimated 16 million sea urchins were consumed by sea otters over a 15-month period from December 1992 through February 1993 (Davidson, et al., 2008).

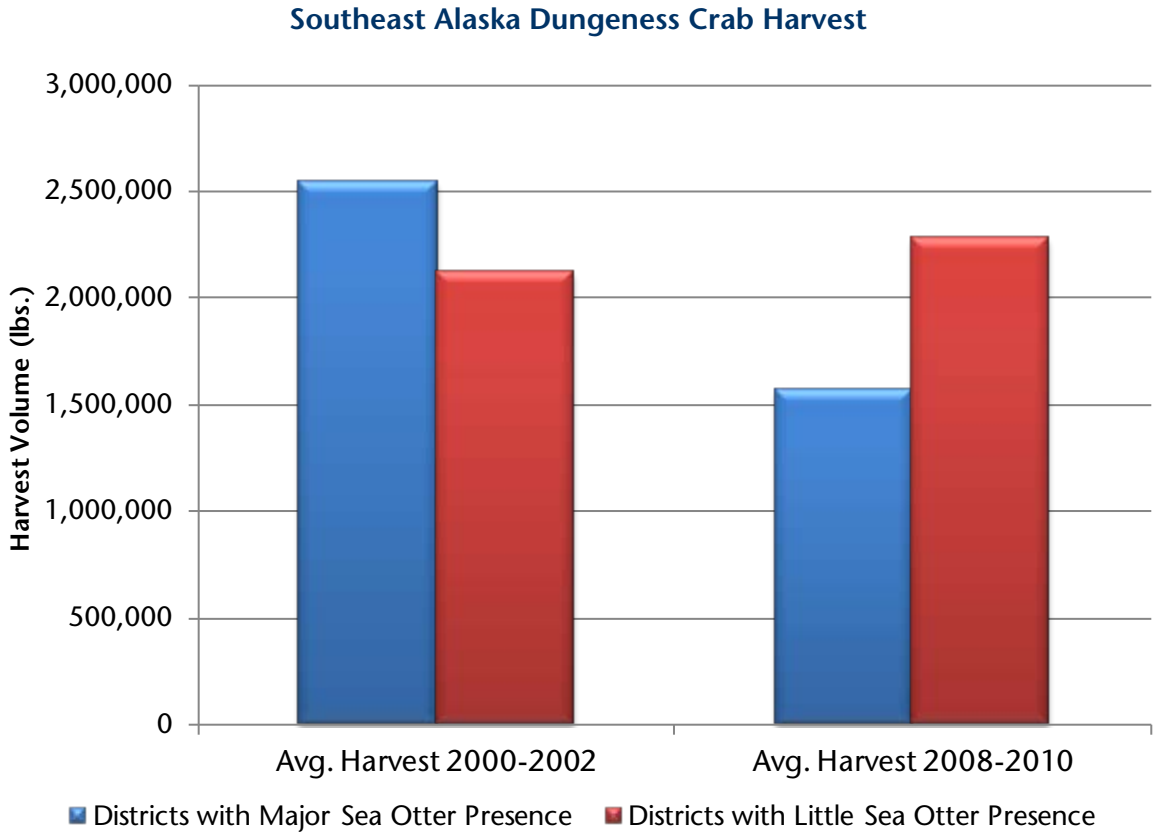
Although the majority of the red sea urchin fishery will go unharvested this season, sea otters are still having a large impact on the biomass. The 2011/12 GHL is 3.3 million pounds; a 42 percent decline from the 2006/07 season (which marks two fishery area rotations). If this trend continues, the fishery may not improve regardless of market price.

Dungeness Crab

Dungeness crab are a substantial food source for otters. Dungeness crab are typically found at depths of 15 to 100 feet, are plentiful in many Southeast Alaska estuaries, and offer a good nutritional return per unit of energy expended.

It is clear areas with a significant sea otter presence have fared much worse in recent years than areas which are not near large sea otter populations. Out of 15 shellfish districts in Southeast Alaska, six have significant sea otter populations or include translocation sites (where sea otters were released in the 1960s).

These six districts have lost nearly 1 million pounds of harvest activity while districts without sea otters have seen harvests increase slightly since the early 2000s. The greatest loss comes from District 9, near Kake, which had a harvest decline of 776,000 pounds from 2007 to 2010 alone.



Note: Districts with major sea otter presence include districts: 3, 5, 6, 9, 10, and 13.
Source: ADF&G harvest data.

It is very likely sea otter predation is the driving force behind the majority of these lost harvest volumes. Fishermen and biologists note the effect of sea otter predation. Not surprisingly, fishermen are leaving the fishery. The Wrangell-Petersburg census area, which includes Kake and the surrounding waters, was home to fishermen who landed crab under 134 Dungeness crab permits in 2005. By 2010, only 111 permits were fished – a loss of 23 permits or roughly 46 jobs (including 1 crew member and the skipper).

According to the Alaska Department of Labor and Workforce Development, the Southeast Alaska crab fisheries employed 638 workers in 2009. The majority of these jobs are in the Dungeness crab fishery. Expanding sea otter populations seriously jeopardize these jobs.

Methodology For Estimating Dungeness Crab Harvest Lost to Sea Otter Predation

Using field research done by ADFG, USFWS, and UAF, several Dungeness crab harvest districts were identified, which included waters known to have significant populations of sea otters. Crab harvests from these areas were compared to harvests in other districts. In effect, districts with fewer sea otters were treated as a control group. If sea otter predation was a serious issue in the areas identified, the harvest of crab should decrease in those districts relative to harvests in other districts (with fewer otters). This is exactly what took place from 2000 to 2010.

Impact of Sea Otter Predation

Districts 3, 5, 6, 9, 10, and 13 – located in southern part of the region and the outside coast line, have lost out on an estimated 2.7 million pounds of Dungeness crab since 2000. It is assumed all or most of this loss is associated with sea otters, as there are no other known factors which affect crab biomass in these districts and not others in Southeast Alaska.

In 2000, these six districts with large sea otter populations, accounted for 61 percent of the Southeast Alaska Dungeness crab harvest. By 2010, they accounted for just 33 percent; after seeing a gradual decline throughout the decade relative to districts without large sea otter populations.

Since 2000, the lost harvest volume attributed to sea otters was worth $5.3 million in wholesale value and $3.3 million in ex-vessel value.

Estimated Dungeness Crab Harvest and Value Lost Due to Sea Otters in Southeast Alaska, 2000/01 – 2010/11

	Estimated Harvest Lost Due to Sea Otters (live wt.)	Estimated Ex-Vessel Value Lost Due to Sea Otters	Estimated Wholesale Value Lost Due to Sea Otters
Total	2,681,000	$3,317,000	$5,301,000

Source: ADFG harvest data and McDowell Group estimates.

Quantifying the Impact of Sea Otter Predation

Dive fisheries in Southeast Alaska are managed by the Alaska Department of Fish and Game. Management is supported by a tax on the ex-vessel value of red sea urchins, sea cucumbers, and geoducks. This tax is used to pay for management staff and perform scientific dive surveys that allow managers to monitor the biomass of commercial species in established subdistricts, or new harvest areas.

Dive surveys are performed by SCUBA divers surveying established, or new, subdistricts along 2-meter wide transects running perpendicular to the shoreline. To complete transects, divers swim along the transect holding a 2-meter rod made of white PVC pipe in a horizontal position. Transect direction is maintained by a compass mounted on the rod.

Every harvest area gets surveyed before a fishery is opened for a given season, in addition to a group of control areas which are surveyed every year. The harvest areas, or subdistricts, open on a rotational basis, depending on the species and results of the dive surveys.

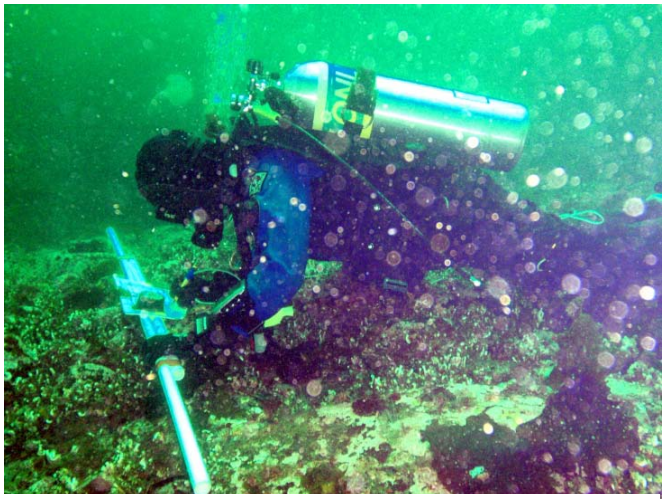


Photo Credit: Alaska Department of Fish and Game.

Dive surveys are expensive, but necessary for sustainable fishery management. In addition to providing data on the biomass, size, and density of commercial species, the dive surveys also allow managers a chance to maintain data on the invertebrates' habitat and eco-system. Divers have noted the presence and evidence of sea otter predation on each transect for each species, in each fishery area. Areas affected by sea otters are often distinguished by large holes with clam shell fragments (from where an otter has dug up a geoduck) or sea urchin carcasses littering the seabed. In the case of sea cucumbers, no physical evidence is left because otters consume the entire animal. However, divers note areas with active sea otter predation and have attributed large biomass declines in various subdistricts to sea otters.

Detailed survey data from thousands of dives recorded by fishery biologists, combined with information on historical biomass and GHL's, allows for a conservative estimate of sea otter predation. The estimated harvest volume lost due to sea otter predation can be translated into dollar terms by applying the ex-vessel price or wholesale price of a particular species in a given year.

Because virtually 100 percent of the GHL is harvested in the geoduck and sea cucumber fisheries, only the lost GHL is calculated and financial impacts are based on GHL. In the red sea urchin fishery, harvests volumes have not historically met the GHL. Therefore, impacts on the red sea urchin fishery were adjusted to reflect dollars and pounds lost are based the assumed harvest, and not on the GHL.

Accurately quantifying the impact of sea otter predation is only possible because ADFG data on sea otter predation, affected areas, commercial harvests, biomass, and market values is very good.

Because of ADFG's rigorous data collection, these estimates are believed to accurately portray the real, direct impact of sea otters on commercial species. Without such data, other studies such as Loomis (2006) have attempted to explain the value of sea otters in terms of existence value or the value of the public's "willingness to pay." These estimates are theoretical and obtained by surveying a sample of the population about what dollar value they place on knowing a certain species, in a certain locale, is flourishing or what dollar value they *would* pay to engage in a suggested recreational activity involving the species. In contrast, the effect of sea otter predation on commercial divers, seafood processors, and Southeast Alaska communities is not hypothetical.

Sea Otter Predation Impacts on Communities

Sea otter predation has led to an estimated loss of $22.4 million in wholesale value for southern Southeast Alaska communities since 1995. Lost sales for fishermen and processors are estimated to have resulted in indirect and induced losses of $5.8 million during that time. These losses reflect lost economic activity in industries outside the seafood industry in southern Southeast Alaska, resulting from lower wages, less household spending by affected families, less spending on indirect business costs, and less taxes collected from fisheries.

In total, sea otter predation is estimated to have cost southern Southeast Alaska communities $28.3 million since 1995. Any revenue derived from eco-tours, expanded subsistence harvests (above what would normally occur), or economic activity associated with scientific studies, stemming from sea otter expansion have likely been negligible, in comparison.

Southern Southeast Alaska Communities Most Affected by Sea Otter Predation

Ketchikan	Sitka	Kake
Petersburg	Craig	Port Alexander
Klawock	Hydaburg	Wrangell

The livelihood of Southeast Alaska commercial divers, crab fishermen, tender operators, and seafood processing workers is currently being jeopardized by expanding sea otter populations. These include hundreds of basic sector jobs which form the foundation of a regional economy.

Residents of the Wrangell-Petersburg census area have seen 23 fewer permits fished in recent years, part of which may be attributed to sea otter predation. Employment has not declined substantially in the sea cucumber and geoduck fisheries, but sea otter predation is estimated to have cost each geoduck diver $20,000 and each sea cucumber divers $7,000 in 2010. Based on the estimated value of product lost in recent years and the amount of economic activity resulting from the typical full-time job in southern Southeast Alaska, the secondary impacts of sea otter predation has been equivalent to a loss of 5 to 10 full-time average-paying jobs (depending on the year).

The wholesale value of Southeast Alaska sea cucumbers, geoducks, red sea urchins, and Dungeness crab was roughly $25 million in 2010. These fisheries employ roughly 625 fishermen and dozens more tender operators and processing workers. Using economic multipliers developed by IMPLAN[2], it is estimated the $25 million in wholesale value associated with these fisheries results in indirect and induced activity worth $6.5 million - equivalent to 53 additional full-time average-paying jobs[3]. Just like commercial divers and crab fishermen, these jobs are at risk of being lost as well. Indirect losses are more often more difficult to see, but they are economically real, as less money circulates in the economy leading to contracting employment.

[2] IMPLAN is an economic modeling software package widely used to perform economic impact analysis.

[3] The estimated number of jobs created is calculated by dividing the value of the secondary impact ($6.5 million) by the average output created per full-time equivalent (FTE) job in Southeast Alaska ($123,992 per FTE job). Therefore, the term "average-paying" refers to a full-time job producing an average amount of economic output, and paid accordingly.

Literature Referenced

Alaska. Department of Fish and Game, Division of Commercial Fisheries. Preliminary Report to the Alaska Board of Fisheries: Collapsed or Recovering Shellfish Fisheries in the State of Alaska. Regional Information Report 1J02-06. October 1999.

Barnes, Jennifer. 2002. Sea Otter Foraging and Feeding Behaviors: A Review. Prepared for the U.S. Marine Mammal Commission. 27 pp.

Davidson, B., E. Coonradt, S. Walker, B. Meredith, J. Breese, D. Harris, T. Thynes, S. Forbes, M. Pritchett, Z. Hoyt. Annual Management Reports of the 2004/2005, the 2005/2006, and the 2006/2007 Southeast Alaska Commercial Fisheries for Geoduck Clams, Red Sea Cucumbers, and Red Sea Urchins. Alaska Department of Fish and Game. May 2008.

Doherty, Phil. Executive director of SARDFA and former ADFG biologist. Personal communication. November 23, 2011.

Hoyt, Z., V. Gill, G. Eckert, S. Rice. "Recolonization, prey selection and resource competition by sea otters, *Enhydra lutris,* in southern southeast Alaska." November 2010 presentation.

Loomis, John. 2006. Estimating Recreation and Existence Values of Sea Otter Expansion in California Using Benefit Transfer. *Coastal Management*, 34: 4, 387-404, First published on: 01 December 2006.

Pitcher, K.W. 1989. Studies of Southeastern Alaska sea otter populations: distribution, abundance, structure, range expansion, and potential conflicts with shellfisheries. USFWS Cooperative Agreement No. 14-16-0009-954. Alaska Department of Fish and Game, Anchorage. 65pp.

Pitcher, K. W. and K.K. Imamura 1990. Impacts of sea otter predation on Dungeness crab abundance in Cross Sound-Icy Strait Area, southeastern Alaska. U.S. Fish and Wildlife Service Cooperative Agreement No. 14-16-009-954 Final Report:1-18.

Pritchett, M. and Z. Hoyt. Report to the Board of Fisheries, Miscellaneous Dive Fisheries. Alaska Department of Fish and Game Fishery Management Report No. 08-63. December 2008.

Paul, Thomas W. 2009. Game transplants in Alaska. Alaska Department of Fish and Game, Technical Bulletin #4, p108.

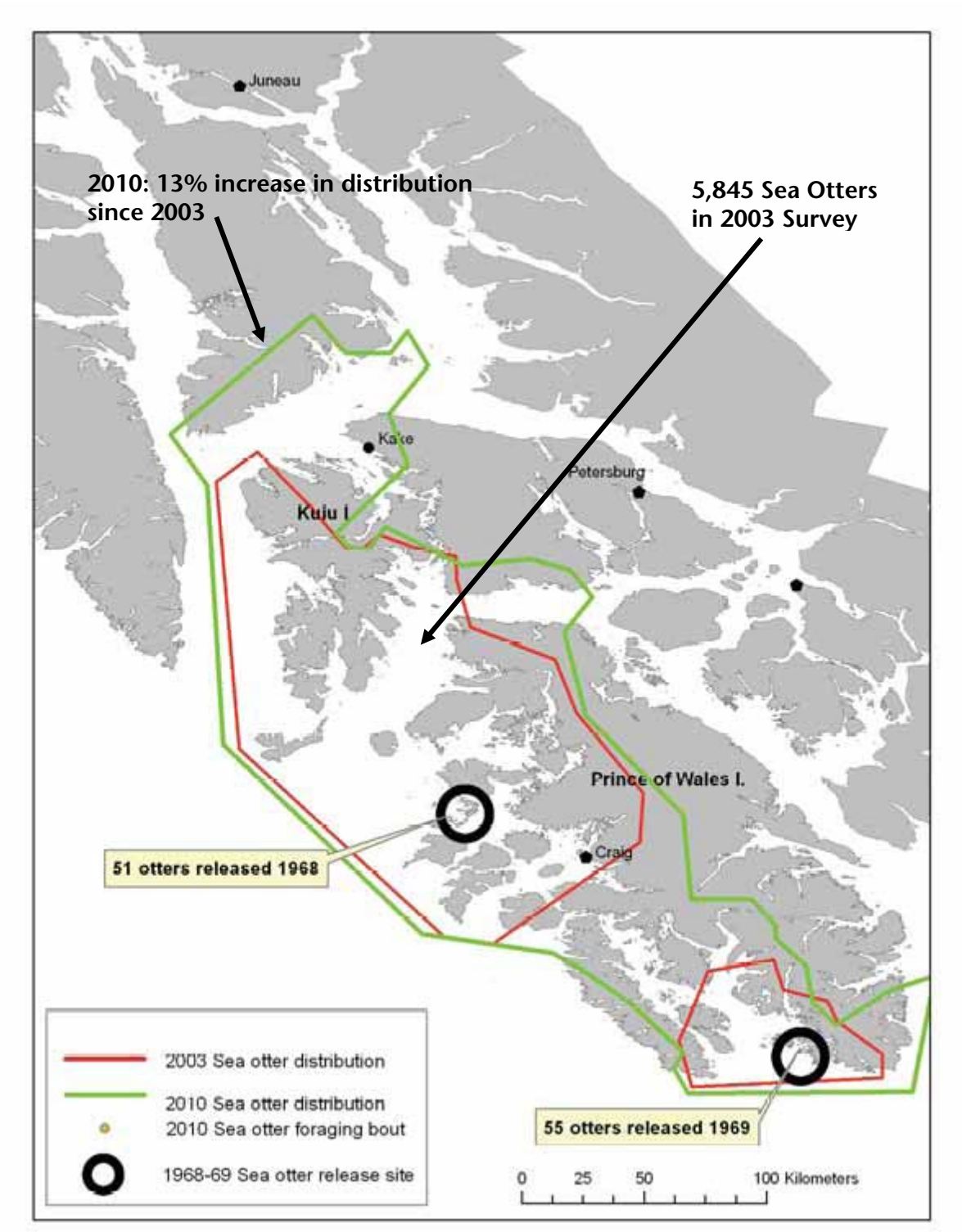
Rumble, J. and C. Siddon. Southeast Alaska 2009 Geoduck Stock Assessment. Alaska Department of Fish and Game. October 2011.

Walker, S., M. Pritchett and Z. Hoyt. 2006. Report to the Board of Fisheries, Miscellaneous Dive Fisheries. Alaska Department of Fish and Game Fishery Management Report No. 06-01:4.

Watson, J.C. and T.G Smith. 1996. The effect of sea otters on shellfisheries in British Columbia: *In:* Invertebrate Working Papers. Reviewed by the Pacific Assessment Review Committee (PSARC) in 1993 and 1994. Ed. by C.M. Hand and B.J. Waddell. Can. Tech. Rep. Fish. Aquat. Sci. No. 2089 pp2 262-303.

Watson, J. 2000. The effects of sea otters (*Enhydra lutris*) on abalone (*Haliotis spp.*) populations. *In* Workshop on Rebuilding Abalone Stocks in British Columbia. *Edited by* A. Campbell. Can. Spec. Publ. Fish. Aquat. Sci. 130. pp123-132.

Appendix 1: Map of Otters in Southeast Alaska



Source: Hoyt, Z., Gill, V., Eckert, G., Rice, S., "Recolonization, prey selection and resource competition by sea otters, *Enhydra lutris,* in southern southeast Alaska." November 2010 presentation.

Appendix 2: Impact of Sea Otters on Dive Fishery Areas

Sea Cucumbers

Fishery Areas Negatively Affected by Sea Otter Predation

Fishery Area	Subdistrict(s)
Cape Chacon	102-10
Cordova Bay	103-11, 15
Long Island – Cordova Bay	103-21, 30
Hetta and Nutkwa	103-23, 25
Eastern Shore of Dall Island and Soda Bay	103-40-001, 002, 004
Bucarelli Bay	103-50
St Nicholas Channel	103-60, 70-002
Boca and Tonowek	103-80
West Dall Island	104-10, 20, 30
Port Camdon	109-43, 105-32
Deep Inlet and Sitka Sound South	113-38, 41
Sitka Sound North	113-40, 42, 43

Areas Closed Due to Sea Otter Predation

Fishery Area	Subdistrict(s)
Sea Otter Sound	103-90
Affleck Canal and Port Beauclerc	105-10, 20
Shaken Bay	105-41, 42
Saginaw and Security Bay	109-44, 45
Tebenkof Bay	109-62
Baranof Island	113-31, 32, 33
Khaz Bay	113-71, 72, 73

Geoduck Clams

Fishery Areas Negatively Affected by Sea Otter Predation

Fishery Area	Subdistrict(s)
Kaigani Strait	103-30-001
Tlevak Strait	103-40, 50-009
South Cordova Bay	103-11
Bucareli Bay	103-50-003
Cone Island North	103-50-005, 104-40-005
Cone Island South and Paloma Pass	103-50-006, 104-35-006
Port Rea Marina	103-50-007
Portillo Channel	103-50-008
Port Mayoral (Control Area)	103-50-CON
East San Fernando Island	103-60-001
Maurelle Islands	103-70, 80, 104-40, 50-009
Ulitka Bay	103-70-001
Little Steamboat Bay	103-70-002
Steamboat Bay	103-70-003
Blanquizal Island	103-70-005
Palisades Islands	103-70-006
St. Nicholas Channel and North Lulu Island	103-70-007
Port Alice and Cone Bay	103-90-002
Turn Point	103-90-003
Davidson Inlet	103-90-004
Warren Island and Kosciusko Island	103-90-005, 105-41, 43, 50-005
Northwest Dall Island	104-20, 30-003
Port Santa Cruz	104-30-002
Taigud and Kolosh Islands	113-31, 41-004
Symonds Bay	113-31-002
Biorka and Legma Islands	113-31-003
Elovoi, Golf, and Gornoi Islands	113-31-005

Red Sea Urchins

Fishery Areas Negatively Affected by Sea Otter Predation

Fishery Area	Subdistrict(s)
Lower Clarence Strait	102-20
Tlevak Strait	103-40
Central Dall Island	104-20-001

Areas Closed Due to Sea Otter Predation

Fishery Area	Subdistrict(s)
Cape Chacon	102-10
Dixon Entrance and Kaigani Strait	103-30
Bucareli Bay and Port Real Marina	103-50
St. Nicholas Channel	103-70
Southwest Dall Island	104-10
Meares Passage and Bucareli Bay	104-30
Western Baker Island and Cone Island	104-35
Western Noyes Island and Cone Island	104-40
Whale Bay	113-22
Baranof Island	113-11, 21