AGENDA C-5
DECEMBER 2000

MEMORANDUM

TO: Council, SSC and AP Members

FROM: Chris Oliver
Acting Executive Director

DATE: November 29, 2000

SUBJECT: Biological Opinion and Steller Sea Lion RPAs

ESTIMATED TIME
20 HOURS

ACTION REQUIRED

Review BiOp and associated Steller sea lion protective measures and take action as appropriate.

BACKGROUND

In September we reviewed a draft EA/RIR/IRFA containing proposed measures for the Pacific cod fisheries relative to sea lion protection, anticipating action on those measures at a special November meeting. Because the comprehensive Biological Opinion released on November 30 has overtaken and subsumed those potential measures specific to the cod fisheries, that package is no longer on the table. As you know, on January 25, 2000, the Court ruled that the biological opinion for the 1999 BSAI and GOA Groundfish TAC specifications was arbitrary and capricious as it failed to conduct a sufficiently comprehensive examination of the overall effects of the groundfish fisheries on listed species and designated critical habitat. That Biop and the associated RPAs address all groundfish fisheries, including pollock, Pacific cod, and Atka mackerel.

As of the writing of this memorandum, I am uncertain what actions, if any, will be required by the Council, or what actions may be open to the Council. My understanding is that RPAs contained in the Biop will be implemented by a Secretarial emergency rule for the beginning of the 2001 groundfish fisheries, with limited opportunity for Council changes. Subsequent actions by the Council for the latter half of the fishing season and beyond may be possible, and this could remain a big agenda item for us in future meetings. A separate report from ADF&G is available which provides an overview of state-managed fisheries with reference to Steller sea lions.

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AGENDA C-5
DECEMBER 2000
SUPPLEMENTAL

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BY FAX

RECEIVED
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N.P.F.M.C

November 28, 2000

President Clinton
The White House
Washington, DC

Dear President Clinton,

The Alaska Marine Conservation Council appreciates your interest and commitment to the conservation of the nation's ocean resources and sustainable fisheries. In keeping with these goals, we urge you to support the National Marine Fisheries Service (NMFS) in completing the Comprehensive Biological Opinion regarding the effects of Alaska's groundfish fisheries on the recovery of the endangered Steller sea lion. The agency is scheduled to release this document on Thursday, November 30. We feel that putting the best available science on the table by that deadline is the best way to begin resolving current fisheries management challenges we face in Alaska.

The Alaska Marine Conservation Council is a community-based organization of fishermen, traditional subsistence harvesters, conservationists and other coastal residents whose livelihoods and ways of life are tied to a healthy marine ecosystem. We believe it is imperative that our fisheries be managed for long-term sustainability, the future of our communities, and in a way that accounts for the health of the whole ecosystem.

There have been delays in the past in completing related agency documents and we are concerned there may be delays again this week. We strongly encourage NMFS to meet this week's deadline for releasing the Biological Opinion. We urge the agency to make sure the document clarifies the conservation objectives derived from the scientific analysis of fisheries. Providing this information will help the North Pacific Fishery Management Council and, if necessary, the State Board of Fisheries contribute to the development suitable management measures. We believe that the open process of refining management measures at the North Pacific Fishery Management Council and the Board of Fisheries is an important venue for public participation. It allows Alaskan fishermen and the public an opportunity to provide their insights into the best way to meet conservation objectives while allowing for viable commercial fisheries to continue.

It is our hope that the solution to the Steller sea lion crisis will include conservation-based fisheries within the critical habitat of sea lions that meet both the needs of sea lions and Alaska's fishing communities. In order to find good solutions in a timely way, the biological opinion is needed by the agency's promised deadline of November 30. Further delays in releasing the biological opinion will not serve the public's interest in terms of meeting conservation responsibilities or providing for stable fisheries important to our coastal communities.

Thank you for your attention to this most pressing matter.

Sincerely,

Dorothy Childers

Dorothy Childers
Executive Director

Cc: Penelope Dalton, National Marine Fisheries Service
Governor Tony Knowles
Senator Ted Stevens
Senator Frank Murkowski
Congressman Don Young
Chairman David Benton, North Pacific Fishery Management Council
Chairman Dan Coffey, Alaska Board of Fisheries

The Nutritional Stress Hypothesis As it Relates to Alaskan Pinnipeds

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November 25, 2000

The "nutritional stress hypothesis" is the most widely accepted hypothesis regarding the decline of Steller sea lions (*Eumetopias jubatus*) in the Gulf of Alaska (GOA) and Aleutian Islands (AI). This theory states that the decline of sea lion populations was caused by a decline of suitable prey. Typical symptoms for mammals suffering from nutritional stress include reduced body size, reduced productivity, high mortality of pups and juveniles, altered blood chemistry and specific behavioral modifications. Pup counts and morphometric measurements of Steller sea lions in Alaska show reduced body size and suggest reduced productivity that could be nutritionally based. Juvenile survival also appears to be low, and blood chemistry analysis has shown that Steller sea lions in the GOA/AI exhibited signs of an acute phase reaction, or immune reaction, in response to unidentified physical, psychological and/or environmental stress. Behavioral studies do not indicate an overall shortage of food for adult female sea lions during summer. For the most part, data collected in Alaska suggest that Steller sea lions in the declining regions are nutritionally compromised due to the relative quality of prey available to them, rather than due to the overall quantity of fish per se. This is further supported by captive studies that indicate the overall quality of prey presently available to Steller sea lions in the declining population could compromise the health of Steller sea lions and hinder their recovery.

Contents

1. Introduction to the Nutritional Stress Hypothesis

The most widely accepted hypothesis to explain the decline of Steller sea lions in the Gulf of Alaska and Aleutian has been termed the "nutritional stress hypothesis". This theory states that the decline in the sea lion population was caused by a reduction in suitable prey (Rosen & Trites, 2000b). However, there is no consensus as yet over whether this reflects a reduction in overall prey abundance or simply a change in the relative abundance of different types of prey available to Steller sea lions (Merrick, 1995; Merrick, Chumbley & Byrd, 1997; Rosen & Trites, 2000a).

The following provides an overview of how mammals (which includes seals and sea lions) respond to nutritional deficiencies. It also reviews evidence of these signs and symptoms in the Steller sea lion and discusses the quality of pre-decline versus present Steller sea lion prey as a possible source of nutritional stress.

1.1 Signs and Symptoms of Mammals under Known Nutritional Stresses

Nutritional stress is not a new or unobserved phenomenon in terrestrial and marine mammals. Signs and symptoms that are indicative of nutritional stress in both groups of mammals include reduced body size, reduced productivity, increased mortality of newborns, increased juvenile mortality, behavioral modifications, and changes in blood chemistry and body composition.

1.1.1 Reduced Body Size

Reduced food consumption can stunt body size in all animals. Humans with eating disorders that result in drastic food reductions suffer low body weights, extremely low body fat percentages and emaciation (Bulik *et al.*, 1999; Mathiak *et al.*, 1999). Laboratory rats with restricted food intakes will attain lower weights due to slower growth rates and less accumulated body fat (McShane & Wise, 1996; Nieuwenhuizen *et al.*, 1999; Peckham, Entenman & Carroll, 1962).

One of the best opportunities for scientists to examine the effect of a known nutritional stress on marine mammals resulted from El Nino events in the mid and south Pacific Ocean. During the 1983 El Nino, a combination of increased sea surface temperatures, reduced upwelling and a depressed thermocline reduced available nutrients to organisms in the euphotic zone. This led to a collapse of primary productivity, which in turn reduced secondary productivity and caused subsequent shortages of prey for many marine mammals. In Peru, this caused a decrease in the abundance of anchovies (*Engraulis ringens*), which reduced the growth of South American fur seal pups (*Arctocephalus australis*) compared to three other years when anchovy stocks were plentiful (Majluf, 1991). Additionally, adult Southern seal lions (*Otaria byronia*) in Peru appeared emaciated during this El Nino event, although measurements were not taken (Majluf, 1991). In the Galapagos Islands, newborn fur seals (*Arctocephalus galapagoensis*) were 10% lighter than those born during non-El Nino years, and several emaciated yearlings were sighted and subsequently disappeared (Trillmich & Limberger, 1985).

Animals faced with reduced food availability or quality will lose body weight, unless they reduce their activity or compensate by depressing their metabolism. This has been shown for captive Steller sea lions, who lost an average of 0.6 kg/d when their energy intake was reduced from approximately 42 to 33 MJ/d (1 J = 0.23866 calories) (Rosen & Trites, 2000b).

1.1.2 Reduced Productivity

A complex web of hormones and feedback systems link reproduction and metabolism (Barash *et al.*, 1996; Barb *et al.*, 1998; Booth, 1990). Animals are less likely to reproduce as nutritional stress becomes acute. In humans and other mammals, this is manifested through irregular estrus or menstrual cycling, prolonged infertility in adolescence, retarded peak fertility and increased occurrence of spontaneous abortions (Bulik *et al.*, 1999; Frisch, Wyshak & Vincent, 1980; Guinet *et al.*, 1998).

The reproductive cycle begins with ovulation and ends with the delivery of a newborn. Reproduction can be terminated at any point along this continuum. However, the critical stage appears to differ among species. For example, in humans, nutritional insult results in cessation of ovulation (Frisch *et al.*, 1980). In pinnipeds, the crucial period seems to be late gestation. Equally critical is the subsequent survival of newborn pups (Trillmich & Limberger, 1985). Frequency of pregnancy during early gestation is not always reduced, indicating that ovulation and fertilization are more resistant to stress in pinnipeds. The late gestation and lactation stages of reproduction are much more energetically costly to females as they support rapidly growing fetuses and newborns in addition to their own metabolic requirements (Pitcher, Calkins & Pendleton, 1998). When food resources are scarce during this costly stage, reproduction and pup survival is jeopardized.

During the 1983 El Nino, the number of Galapagos fur seals born was only 11% of average levels (Trillmich & Limberger, 1985). A decline was also noted during this year of food stress in the number of sea lion pups born (74% of pre-El Nino levels) (Trillmich & Dellinger, 1991). Similarly, northern fur seal pup production decreased by 60% during the 1983 El Nino at San Miguel Island, California (DeLong & Antonelis, 1991). In the southern hemisphere, fewer Antarctic fur seal (*Arctocephalus gazella*) pups appear to be born following a year of food restriction, possibly due to reduced implantation of fertilized eggs (Lunn & Boyd, 1993).

A four year study of South African fur seals (*Arctocephalus pusillus*) found that females who aborted pregnancies were in significantly poorer body condition (as indicated by a low body condition index) (Guinet *et al.*, 1998). This was not found in fur seals of normal body condition. This study also found a significant positive relationship between body condition and the probability of being pregnant in late gestation. This and the other three studies of pinnipeds demonstrate that nutritional stress can reduce body size and condition, which in turn can reduce the number of pups born. The extent of such effects is related to the intensity of the nutritional stress.

1.1.3 Reduced Pup Survivorship

Trillmich *et al.* (1985) reported that only 67% of newborn fur seal pups survived their first month of life and that 100% died within the first five months during the 1983 El Nino in the Galapagos Islands. In contrast, during the non-El Nino years of 1979-1981, when food was abundant, survival was 95% during the first month and 80% during the first year. The Galapagos sea lion (*Zalophus californianus wollenbaeki*) also experienced high pup mortalities during 1983, with only 14% surviving versus 95% in typical years (Trillmich & Dellinger, 1991). When faced with food shortages, mothers are often only able to allocate enough resources to meet their own metabolic needs. Thus, it is the young offspring of these females that suffer most dramatically.

1.1.4 Reduced Juvenile Survivorship

Juvenile pinnipeds that forage on their own are faced with greater nutrition related challenges during food shortages compared to older more experienced individuals. Adults have the ability to greatly increase the time and distance of their foraging trips. They can also execute deeper dives. In contrast, juveniles are usually inexperienced foragers and may not be able to increase their foraging effort through these adaptations (Merrick, 1995). Their survival is therefore of great concern.

The 1983 El Nino was particularly hard on juvenile Galapagos fur seals and sea lions. Juvenile sea lion survival was only 20% of normal during this time of extreme food shortage. Seven of nine fur seal yearlings appeared starved and later disappeared. None of 143 two-year-old seals returned to their colonies, and only six of twelve three-year-olds returned. They were presumed to have starved at sea (Trillmich & Limberger, 1985). Adult female numbers, on the other hand, were only reduced by 27%. These older animals were likely better able to seek out prey during the shortage, thereby buffering the effects of El Nino by modifying their foraging behavior.

Scheffer (1950a) reported one year when high numbers of emaciated yearling northern fur seals (*Callorhinus ursinus*) washed ashore. Their deaths were probably due to harsh winter conditions, low fat reserves, and their inability to forage effectively in rough seas. Similar observations were not made for adult fur seals suggesting that juveniles are more vulnerable than adults to changes in prey availability.

1.1.5 Blood Parameters

There are several plasma and hematological tests for nutritional stress in marine mammals. For example, malnutrition in northern fur seal pups is marked by viscous blood and dehydration in all tissues (Keyes, 1965). In Steller sea lions, glucose, non-esterfied fatty acids (NEFA) and β-hydroxybutyrate (ketone bodies) reflect carbohydrate and fat utilization respectively (Rea *et al.*, 1998). Levels of NEFA and ketone bodies are elevated when an animal fasts, and drop as an animal enters Phase III starvation[1] (Bradley, Wright & McGuire, 1993). Elevated levels of blood urea nitrogen (BUN) are a measurable sign of this third phase.

[1] Phase III starvation is defined as the last stage of starvation when both glucose and fat stores are depleted and an animal begins to use its protein stores (ex. muscles) as an energy source (i.e. Rea, 1995).

In northern elephant seals (*Mirounga angustirostris*), extreme fasting has been shown to increase blood ketone (β-hydroxybutyrate) levels (Castellini & Costa, 1990). Blood chemistry on ten wild grey seal pups (*Halichoerus grypus*) showed the expected depressed glucose, and elevated NEFA and ketone body levels during a 52 day fast (Nordoy & Blix, 1991; Nordoy, Ingebretsen & Blix, 1990). This is similar to two abandoned, and clearly emaciated Steller sea lion pups in Alaska that showed elevated ketone and fatty acid levels indicative of Phase II starvation where fat stores are metabolized. Two other abandoned pups showed signs of Phase III starvation, demonstrating that these blood parameters are good indicators of nutritional stress in pinnipeds (Rea, 1995). Finally, Hubbard (1968) reported BUN levels in an anorexic juvenile Steller sea lion at 160 mg%, compared to normal values of 9-30 mg%.

1.1.6 Behavioral Modifications

Animals will modify certain behaviors to reduce nutritional stress and conserve energy and body condition when faced with food shortages or poor quality food. For example, rats fed low-fat diets *ad libitum* will maintain body mass by increasing daily food intakes to make up for the low caloric content of their food (Harris, 1991). If rats and other mammals cannot increase their food intake, they may depress their metabolism, reduce activity levels or increase foraging effort (Milette, 1999; Rosen & Trites, 1999).

Metabolic depression (decreased basal metabolic rate) has been documented in northern fur seals and Steller sea lions during periods of restricted food intake. Captive northern fur seal pups were found to reduce their basal metabolism to half of its initial value within a week of the onset of fasting (Nordoy *et al.*, 1990). This reduction was attributed to depressed cellular metabolism versus a loss of metabolic tissue through weight loss. When transferred from an energy dense diet (meaning a high fat and high calorie diet) to a low fat diet, the resting metabolic rate of captive Steller sea lions decreased by 10% after one week and by 24% after two weeks (Rosen & Trites, 1999). Metabolic depression is a strategy used by these marine mammals to reduce energetic requirements and compensate for nutritional deficiency.

During the 1983 El Nino, South American fur seals in Peru exhibited longer foraging periods (4 versus 3 days) and made more frequent deep dives when prey were scarce (Majluf, 1991). Galapagos fur seals also increased the time they spent foraging when prey were scarce, subsequently lengthening their time away from their sedentary pups on the beach. These longer foraging periods were energetically costly for the females, and resulted in starvation of their unfed pups during their absence (Trillmich & Dellinger, 1991). In California during this same El Nino, the lengths of maternal foraging trips of northern fur seals increased significantly compared to non-El Nino years. California sea lions also increased the length of their foraging periods (1.7 to 3.9 days) and the amount of time they spent at sea (5% increase in 1983 over 1982) (Heath *et al.*, 1991). During such extreme food shortages, behavioral modifications were clearly documented and consistent in many species of pinnipeds.

2. Evidence for Nutritional Stress in Steller Sea Lions of Alaska and other Marine Mammals

The most common and consistent effects of nutritional stress on mammals have been noted under *severe* circumstances and drastic food shortages. A milder El Nino (1976) did not result in mass starvation and reduced productivity in Galapagos sea lion populations (compared to the 1983 El Nino) (Trillmich & Limberger, 1985). Just how large the nutritional insult must be to noticeably affect blood chemistry, behavior, survival and other variables in not known.

The central question is whether or not the Steller sea lions in Alaska have shown definitive signs and symptoms of nutritional stress throughout their rapid population decline. If so, a secondary question is whether this "stress" was due to reduced quantity or quality of their prey. The following summarizes the evidence to date of nutritional stress in Steller sea lions.

2.1 Reduced Body Size in Steller Sea Lions in Alaska

The rapid decline in Steller sea lion numbers is thought to have commenced in the eastern Aleutian Islands in the 1960s and spread throughout the Aleutian Islands and the Gulf of Alaska by the late 1970s. The exception to this trend in Alaska was in southeastern Alaska (Merrick, Loughlin & Calkins, 1987; Trites & Larkin, 1996). Some morphometric and food habit data were collected before (1975-1978) and during (1985-1986) the most dramatic stages of this decline (Calkins & Pitcher, 1982; Calkins & Goodwin, 1988). Additional data have been collected throughout the 1990s.

Steller sea lion body weights, standard lengths and axillary girths were all significantly smaller in animals aged 1-10 years during the population decline (1985-1986) compared to measurements taken prior to the decline (1975-1978) (Calkins & Goodwin, 1988). These changes were independent of reproductive status. In 1985-1986, sea lions 1 to 5 years old were 4.5% shorter and 22.5% lighter than those in the 1970s, and animals 6-10 years of age were 1.2% shorter and 6.9% lighter (Lowry, Frost & Loughlin, 1988).

Theories regarding density-dependent responses predict that body size should have increased as population density decreased if per capita food had increased. The fact that body size decreased during this decline suggests that there was a decrease in per capita food abundance (Calkins & Goodwin, 1988). Such a response further suggests that the carrying capacity of Steller sea lions may be lower now than it was in the past.

The reduction in body size of Steller sea lions in the Gulf of Alaska was concurrent with increases in the occurrence and volume of pollock (*Theragra chalcogramma*) in sea lion stomachs (from ~39% in the 1970s to ~52% in the 1980s). This specific extension of the nutritional stress hypothesis (speculating that the nutritional stress was due to a diet switch from high fat forage fish to low fat gadids) is referred to as the "junk food hypothesis" and is covered in detail in Section 3. For now, it is important to realize that the diets of sea lions changed during the decline, and that the present day diet is significantly different from what was eaten prior to the decline.

Table 1. The estimated reductions in axillary girth and weight in Steller seal lions aged 1, 7 and 14 years in 1985-1986 as compared to 1975-1978 (Calkins *et al.*, 1998).

	% Reduction in axillary girth	% Reduction in weight
Age 1	10.4	26.9
Age 7	6.29	12.3
Age 14	1.7	3.0

The Calkins *et al.* data set of body size measurements was re-examined in 1993 by Castellini and Calkins (1993). They corroborated the conclusion that sea lions were shorter, lighter and thinner in the 1980s than individuals in the 1970s. However, they also noted that the sea lions had less body fat and/or a different body shape as determined by body volume/weight relationships. Such observations are expected for animals that are nutritionally stressed. Furthermore, this reduction in body size seemed to be more apparent in juvenile sea lions than in adults, implying slower growth of the most recent generations due to limited food resources (Sease & Merrick, 1997). Further use of multiple regression models on these length, girth and weight measurements supported the notion that the greatest reductions in size were in the youngest animals (Calkins, Becker & Pitcher, 1998) (Table 1).

Body length is believed to reflect nutritional status during the first 8-9 years of life, while weight and girth likely reflect recent nutritional condition, in addition to lifetime nutrition (Calkins & Pitcher, 1982). Using this argument, the youngest animals were more nutritionally stressed as seen by the magnified reductions in their weights and girths compared to the older animals. Sea lions (age 14 y) capable of successfully foraging for themselves, suffered the least. Less adequate nutrition apparently affected adults later in life versus during their weaning and juvenile years, as evident by their relatively stable lengths (2,312mm versus 2,320mm), but reduced girths and masses.

Recent investigations (1990s) into the health and condition of Steller sea lions have yielded substantially different results than those comparing pre-decline and post-decline morphometrics. The size and body condition of 25 adult females in declining populations (Chirikof Island and Fish Island) were compared to adults in a stable population (Lowrie Island) (Davis *et al.*, 1996). No significant differences were found in standard length, axillary girth or weight among mature females in all areas. Further, their body compositions did not differ, with average lean body weight and total body fat estimated at 91.7% and 8.3% respectively.

Three possible explanations have been offered for these observations of mature females in the Aleutian Islands and southeastern Alaska (Davis *et al.*, 1996). The first is that diminished food resources are not the cause of the Steller seal lion decline (but this is unlikely as the amount of evidence pointing toward nutritional stress far outweighs all speculation to the contrary). The second explanation is that diminished food resources caused the decline, but are now adequate. This is a more probable explanation than the first. Nutritional stress may have decreased for mature females as gadid stocks grew and the rate of population decline slowed (Sease & Loughlin, 1999). The third and final explanation that Davis proposes is that older females have access to food, which is unavailable to juveniles.

The females observed by Davis *et al.* (1996) were lactating mothers and may not be representative of the entire population. The fact that they returned to breed suggests that food was probably not scarce prior to their arrival at the rookery, or their pregnancies would have likely failed. The Davis *et al.* sample may thus have been biased towards observing healthy mothers that maintained pregnancies over the winter and returned to their rookery to give birth. Less fortunate females (i.e., those unable to attain adequate food) could have foregone a reproductive cycle and moved to a haul-out during the breeding season. An alternative explanation is that prey was adequate for all mothers, but not for juveniles as discussed in Section 2.4.

In summary, it has been demonstrated that Steller sea lions were physically smaller during the period of population decline than they were prior to the decline. This holds true for measurements of length, girth, weight and body condition indices, and is consistent with the hypothesis that the Steller sea lion decline was caused by nutritional stress.

2.2 Reduced Productivity in Steller Sea Lions in Alaska

Reduced fertility is a well known outcome of nutritional stress in mammals and involves complex interactions between the metabolic and reproductive pathways (Amico *et al.*, 1998; Aubert *et al.*, 1998; Barash *et al.*, 1996; Barb *et al.*, 1998; Booth, 1990; Brann *et al.*, 1999; Bronson, 1988; Bulik *et al.*, 1999; Coffey *et al.*, 1994; Cunningham, Clifton & Steiner, 1999; Den Hartog & Vesseur, 1993; Keisler, Simmons & Dyer, 1998; Kirkwood & Aherne, 1985; Newton & Mahan, 1992; Nieuwenhuizen *et al.*, 1999; O'Dowd *et al.*, 1997; Pharazyn *et al.*, 1991; Pinilla *et al.*, 1999; Rozeboom *et al.*, 1993; Shaw, Rasmussen & Myers, 1997). One of the repercussions of inadequate nutrition can be delayed first estrus in juveniles resulting in delayed age at first reproduction. It can also lengthen the interval from parturition to the next estrus and result in low birth weights, spontaneous abortions and low survival of newborns.

Fertility parameters such as delayed first estrus, anestrus (temporary termination of estrous cycles) and pregnancy rates prior to parturition can be difficult to measure in wild populations of sea lions, particularly if minimal disturbance of animals is sought. Despite this, some data are available regarding pregnancy rates before and after the Steller sea lion decline. The most common measures of fertility in these populations, however, are pup counts, incidence of abortion and pup size and growth rates.

Pup counts are the most obvious way to measure reproductive success from one year to the next. Pups remain on or near beaches during the early nursing period, making them easy to count accurately. In surveys of Steller sea lions conducted in 1975-1978 and 1985-1986, investigators counted 45% fewer pups in the 1980's than in the 1970's (Calkins & Pitcher, 1982; Calkins & Goodwin, 1988). In the later of the surveys, reduced numbers of pups were counted at *all* rookeries in the Gulf of Alaska between 1984 and 1986. A decline of 11% was even found on Forrester Island, a rookery in southeastern Alaska that was thought to support a stable population. Southeastern Alaska through the central Aleutian Islands experienced decreases in pup numbers of 10.6% between 1994 and 1998, although western stock areas declined by 19.0% and eastern stock areas increased by 12.3%. In this same interval, pup counts from the central Gulf of Alaska through the central Aleutian Islands declined 34%. Even between 1997 and 1998, the western Aleutian Islands experienced an 18% decline in pup numbers.

The noted population declines and reductions in productivity were not unique to the Steller sea lions in Alaska. Between 1950 and 1990, the number of fur seal pups born on St. Paul Island decreased from 451,000 to 201,310 (Anonymous, 1993, Trites & Larkin, 1989; Trites, 1992). Concurrently, the productivity of common and thick-billed murres (*Uria aalge* and *U. lomvia*) decreased by ~40% in the late 1970s to early 1980s in the Pribilof Islands. Productivity subsequently increased in the mid 1980s, but declined again (Anonymous, 1993). Similar trends have been noted throughout the northern ranges of black- and red-legged kittiwakes (*Rissa tridactyla* and *R. brevirostrus*) (Springer & Byrd, 1988).

Pregnancy rates can be estimated using various methods. The primary means of investigating Steller sea lion pregnancy rates has been to examine their reproductive organs (ovaries, uteri, etc.). Estimates yielded early-term pregnancy rates of 95% and 92% in the 1970s and 1980s, respectively, and mid- to late-term pregnancy rates of 67% and 60% (Calkins & Goodwin, 1988). Neither of these comparisons were statistically different, although the substantial failure of pregnancies over the winter in both periods is interesting. This implies that summer conditions may not be stressful, and that nutrition is more critical later in gestation when the energetic costs of pregnancy are much higher. The surprisingly high failure of pregnancies (33-40%) have led some to suggest that nutrition was likely inadequate by the mid-1970s (Calkins *et al*., 1998).

Pitcher *et al*. (1998) further analyzed this reproductive data set to compare the pregnancy rates of lactating and non-lactating females. They noted that although absolute pregnancy rates did not differ between the 1970s and 1980s, the rates did differ when lactational status was considered.

Steller sea lion pups do not appear to wean until they are about almost one full year old (Trites, unpublished data). This means that females that rear pups every year will nurse one pup while pregnant with their next. In the 1970s, lactational status did not appear to affect the probability of a female being pregnant, implying that she was able to obtain sufficient food to simultaneously nurse one pup and maintain a second pregnancy. In the 1980s, however, a female's probability of being pregnant was greatly reduced if she was nursing a pup from the previous year. The reduced body condition of females in the 1980s (Calkins & Goodwin, 1988) combined with the positive correlation between pregnancy status and both weight and blubber indices (Pitcher *et al*., 1998) would have reduced the numbers of pups born and contributed to the population decline of Steller sea lions. Today, it may even hinder their recovery, although such complete data sets are no longer available.

Records of abortions and failed pregnancies are another commonly used index of reproductive success in Steller sea lions. "Reproductive failure" is defined as resorption of an embryo, abortion, or a missed pregnancy where the female did ovulate and either fertilization or implantation failed (Calkins & Goodwin, 1988). As noted earlier, the number of pups born declined significantly between 1975-1978 and 1985-1986, although there was no corresponding decline in pregnancy rates. Calkins and Goodwin (1988) suggest this discrepancy can be explained by an elevated occurrence of reproductive failures during the decline. Aborted fetuses were frequently seen on haul-outs and rookeries in the 1970s. However, it was not known at the time (and still is not known) whether this was the norm or an exception (Calkins & Pitcher, 1982). The 1980's counts revealed similarly high failure rates (approximately 4.7% in the 1970s and 5.4% in the 1980s).

Although pregnancy rates and pup counts provide valuable information about the status of marine mammal populations, they may not be the best indicators of population health. Survival of young during their first year is assured. Pup birth weights and growth rates are useful indicators of reproductive success as they reflect the mothers' condition during pregnancy and how much nourishment the pup is receiving through nursing after parturition. Unfortunately, data are insufficient to conclude whether or not pup birth weights were lower during the Steller sea lion decline. Nor is there data to compare pup growth rates during the 1970s and 1980s. Recent studies have attempted to examine this question through comparisons of pup weights and growth rates in currently declining and stable populations (Brandon, 2000).

Morphometric measurements of Steller sea lions collected from a stable population at Lowrie Island were compared to similar measurements taken from sea lions in the declining populations of Chirikof, Marmot and Fish islands from 1993 to 1995 (Davis *et al.*, 1996). No significant difference was found in pup weight among locations in the first five days of life. All pups averaged 21.0 kg. However, pups from the declining areas of Chirikof and Fish islands grew faster (0.45kg/day and 0.35kg/day, respectively) than those in the stable population (0.20 kg/day). No difference was found in the lean body weight and total body fat between pups or adult females at the different locations, as determined via calculations from total body water. These findings suggest that nutritional stress was not evident at these sites, regardless of their population declines. Similar studies have also found equal birth weights, lengths and girths between these declining and stable populations as well as lower growth rates of pups from Lowrie Island (Brandon *et al.*, 1996; Davis *et al.*, 1996).

Morphometrics of pups were also studied by Rea (1995) at a number of declining (Aleutian Islands and Gulf of Alaska) and stable (southeastern Alaska) breeding sites. She, too, found that pups from the declining Aleutian Island populations were larger in mass and girth than those from southeastern Alaska or the Gulf of Alaska. These Aleutian pups also showed higher body condition indices (girth/length) and lower density indices [mass / (length x girth^2)], implying that they were fatter and heavier for their length than pups in the Gulf of Alaska. This again suggests that adult females obtained adequate nutrition and were able to produce sufficient milk for their pups.

The lack of differences between pups from different areas may reflect low accuracy and precision of measurements and therefore an inability to detect subtle and/or biologically relevant differences in morphometrics. In fact, the condition and density indices used by Rea (1995) were unable to distinguish visibly emaciated, orphaned pups from healthy newborns, illustrating the low sensitivity and reliability of the indices. It should be kept in mind that a healthy condition at five days of age does not ensure successful weaning, survival and foraging efficiency later in life (Rea, 1995). The studies may have been conducted prior to the onset of stress or before signs of stress were evident. Some have hypothesized that it is the juvenile age class that is nutritionally stressed due to a decreased abundance of juvenile/small fish (Alverson, 1992; York, 1994).

2.3 Reduced Pup Survival in Steller Sea Lion Populations in Alaska

Apart from occasional sightings of abandoned pups on Alaskan rookeries (Rea, 1995; Rea *et al.*, 1998), there is no evidence of high mortality of Steller sea lion pups either before or after the population decline. Yet, large numbers of dead pups should have been observed on rookeries if severe shortages of prey were occurring. During the 1982/83 El Nino, shortages of food after parturition caused high pup mortality in three species of pinnipeds. Females were unable to find sufficient resources to continue nursing, although resources had been plentiful the previous spring and winter to allow for the birth of relatively healthy pups (Trillmich & Dellinger, 1991; Trillmich & Limberger, 1985).

2.4 Reduced Juvenile Survival in Steller Sea Lion Populations in Alaska

The concern regarding juvenile survival dates back to the first large scale Steller sea lion surveys by Calkins and Goodwin (1988). The observed rate of decline in adults coupled with an increased average age of adult females was one of the first indications that the younger age classes might be at risk. In the Marmot Island population, for example, the average age of females over three years old increased by 1.55 years in the period from 1975-1978 to 1985-1986 (Anonymous, 1993). Subsequent modeling studies predicted that the observed population decline of Steller sea lions could be due to a 10-20% decrease in juvenile (0-3 years) survival, in addition to a 1-2% decrease in adult survival (York, 1994). Other models suggest that the observed decline could have only occurred if 3,000 to 3,500 females aged 1-7 were removed from the population every year for the past thirty years (Anonymous, 1993). The observations of decreasing numbers of young animals coupled with the modeling exercises have led some to conclude that the population decline could have been caused by reduced survival of juveniles, with no reduction in female fertility (Loughlin, 1998).

This juvenile mortality hypothesis also holds for explaining the northern fur seal decline between 1956 and 1970, and is consistent with the nutritional stress hypothesis. Simulation models have suggested that a combination of female harvests and poor juvenile survival were responsible for causing and maintaining reduced pup production on St. Paul Island (Trites & Larkin, 1989). The more recent decrease in pup production is also attributed to inadequate juvenile survival. The consequences for juveniles faced with limited food are starvation or reduced growth rate. Increased mortality directly affects population numbers, but reduced growth rates have indirect and less obvious effects on population numbers. Slower body growth may delay maturation and the onset of estrous cycling. Such a delay could result in females not having pups for an additional year or two, which would delay their contribution to population growth. This alone may not have caused the decline, but could certainly hinder its recovery.

Direct evidence of low juvenile survival comes from a mark-resighting experiment in 1987/88 and 1992 (Fritz, Ferrero & Berg, 1995). Prior to weaning, 424 female Steller sea lion pups were tagged. It is known that females have a strong fidelity to their native rookery, and that a good proportion of these pups should return to their rookery in three to four years. While expectations were that approximately 100 of the marked females would return, only 15 were sighted. A similar study in which 800 pups were branded in 1987/1988 on Marmot Island yielded sub-adult and adult (5-10 years) returns that were an order of magnitude lower than expected (Sease & Merrick, 1997).

Reduced proportions of juveniles relative to adults at haul-outs and rookeries provide additional evidence that inadequate juvenile survival may have, and may still be contributing to the decline. For example, at Marmot Island in the Gulf of Alaska, proportions of juveniles counted in June dropped from 15-20% in the 1970s, to 5% or less in the 1990s (Sease & Merrick, 1997). The latest reported surveys (Sease & Loughlin, 1999) showed that the number of non-pups at haul-outs increased between 1991 and 1999 in the western Gulf of Alaska and the eastern and central Aleutian Islands. This could be interpreted in two very different ways. On one hand, it could mean that there has been an increase in the relative abundance of juveniles in these populations, which would benefit the recovery of sea lions. Alternatively, this could reflect an increase in the number of non-breeding females.

Vital parameters that could result in a decline in productivity and an increase in adult numbers on haul-outs versus rookeries include 1) delayed onset of reproduction, 2) increased intervals between births, 3) reduced success of pregnancy in late gestation and 4) reduced survival of adult females (Sease & Loughlin, 1999). Increased intervals between births are evident through the reduced probability of late-term pregnancy in lactating females (Pitcher *et al.*, 1998). Reduced success of late-term pregnancy in females between pre-decline and decline populations was also discussed earlier (Calkins & Goodwin, 1988). Both studies indicate that the relative increase in non-pup numbers at haul-outs could be due to reduced numbers of reproductive females. Confirmation of this, however, requires that the composition of these "non-pups" be divided into "adult" and juvenile" numbers. Counts of non-pups skewed towards juveniles might be a good indicator of recent, strong juvenile age cohorts. Numbers skewed toward adults might reflect an increase in non-reproductive adult females, as females with pups would be present at rookeries, and not haul-outs. Such possibilities reflect the need to be cautious about interpreting counts of juveniles or non-pups (Calkins, Pendleton & Pitcher, 1996). Juveniles are highly active and may spend a large proportion of their time offshore, which would easily bias counts (Pascual & Adkinson, 1994).

What has not been discussed as of yet is the mechanism behind possible reduced juvenile survival and its connection to the nutritional stress hypothesis. Juvenile Steller sea lions are believed to prey on smaller fish than adults, namely juvenile pollock and small forage fish (Merrick, 1995). The last three decades, however, have witnessed dramatic declines in forage fish such as herring (*Clupea pallasi*) and capelin (*Mallotus villosus*) (Alverson, 1992). What is less well known is that the numbers of juvenile pollock also decreased through the 1980s and 1990s, despite the large increase in overall pollock biomass (Alverson, 1992). Adult sea lions may have dampened the effect of reduced numbers of small forage fish by behaviorally modifying their dives to catch the deeper adult pollock and cod. Due to lack of experience or ability, juveniles may be less adept foragers and unable to greatly increase the depth of their dives (Merrick, 1995).

The combination of low numbers of small forage fish and reduced quantities of juvenile gadids could leave juvenile Steller sea lions food limited. Competition for these fish may have also increased in the face of reduced overall numbers of juvenile pollock. Adult pollock and cod abundance have increased dramatically, and these two piscivorous fishes may be major competitors of sea lions for juvenile pollock. Other species such as flounder, sole, halibut, kittiwakes, murres, fur seals and other pinnipeds all compete for the declining numbers of small pollock (NMFS, 2000). Thus, competition for a low-energy prey that must be consumed in substantially higher amounts (see Section 3) could result in serious nutritional stress for juvenile Steller sea lions.

2.5 Blood Parameters in Steller Sea Lions in Alaska

Evidence of nutritional stress in Alaskan Steller sea lions and other marine mammals based on blood chemistry is presently inconclusive. Thompson *et al.* (1997) discovered that leukocyte counts were lower during years of low abundance of clupeids (e.g. herring) and high abundance of gadids in the diets of European harbor seals, compared to years of high clupeid abundance. These differences could be attributed to immuno-suppression from differences in nutritional value or contamination levels of prey, or to differing pathogen challenges in the water between years and regions. Additionally, Thompson *et al.* found evidence of widespread macrocytic anemia in years of high gadid consumption, which could be due to acclimation to different diets or differences in the nutritional quality of the prey.

A comparison of hemoglobin (Hb) values and packed cell volumes for sea lions in the 1970s and 1980s found both to be lower in the decline era, although only hemoglobin differences were significant (Calkins & Goodwin, 1988). Lowered Hb values were interpreted to indicate widespread clinical anemia due to nutritional stress. It was considered unlikely to be due to blood loss via parasitic insult or chronic bleeding, and more likely a result of vitamin and mineral deficiencies, failure of intestinal absorption and/or hypoproteinemia in a deficient diet.

Haptoglobin (Hp) is one of a group of blood proteins that increases markedly in response to infection, inflammation, trauma or tumors, in what is known as the "acute phase reaction" (Zenteno-Savin *et al.*, 1996). Analysis for this protein is non-specific with respect to the cause of the stressor, but is very sensitive and useful in diagnosing the health of many mammals. Levels of Hp in Steller sea lions were significantly higher in animals of all ages from declining populations when compared between the Aleutian Islands/Gulf of Alaska (declining population) and southeastern Alaska (stable population). They were also found to be higher for harbor seals from Prince William Sound (declining) than for harbor seals in southeastern Alaska (stable) (Zenteno-Savin *et al.*, 1996). This is some of the first evidence from blood chemistry that one or more stressors may have initiated an acute phase reaction in Steller sea lions.

Blood testing for metabolic parameters has yielded very different results. Normal blood ketone body levels, glucose levels and blood urea nitrogen levels were found in newborn pups on Marmot Island in 1990 and 1991, contrary to the idea that these animals were food restricted (Bradley *et al.*, 1993). Similar measurements in pups in the Aleutian Islands, Gulf of Alaska and southeastern Alaska showed no evidence of nutritional stress in pups from declining areas, and suggested superior condition of these young in 1990-1996 (Rea *et al.*, 1998).

Again, it needs to be repeated that the blood chemistry analyses, like so many other measurements, were taken after a significant reduction in the rate of population decline. Furthermore, there would be no evidence of nutritional stress in newborn pups if the older juvenile cohort were the age class most affected by prey limitations. Additionally, values such as blood ketone bodies and glucose levels can change rapidly and may reflect conditions on small time scales that are not biologically relevant. Previous tests of haptoglobin (Zenteno-Savin *et al.*, 1996) may be much more useful indicators of condition, although they reflect non-specific stressors rather than metabolic condition.

2.6 Behavioral Modifications in Steller Sea Lions in Alaska

When faced with limited food sources, there is evidence that pinnipeds will increase their foraging effort, increase foraging trip lengths, decrease the perinatal period (time from parturition to mother's first feeding trip), depress metabolic rates and provide less care (suckling) for pups. These behaviors were clearly documented during the 1983 El Nino in California, South America, and the Galapagos Islands (and were briefly reviewed in Section 1). Studies examining similar parameters in the Steller sea lions in Alaska are relatively few, and most have been conducted in the last five years, after a significant reduction in the rate of population decline.

Comparisons of maternal attendance patterns and foraging behavior were made between animals of Sugarloaf Island (declining population) and Lowrie Island (stable population) in 1994 and 1995 (Milette, 1999). Despite the declining status of the Sugarloaf Island population, longer perinatal times and longer first shore visits of the mothers were recorded, counter to food-limitation expectations. Foraging trips were significantly shorter (19 hours versus 25.6 hours) at Sugarloaf Island compared to the increasing Lowrie Island population, and lactating females spent less time foraging at sea (35.9% versus 38.9%, respectively). All of these behaviors suggest that females in the declining population were not having difficulty finding prey. However, Milette suggests that differences in the relative abundance of major prey items may explain the differences in duration of foraging trips.

Sea lions from colonies in the area of decline have fed on primarily walleye pollock and Atka mackerel (*Pleurogrammus monopterygius*) since the 1980s (Merrick *et al.*, 1987). Those in stable regions have been preying on a more diverse diet of Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*) and smelts (*Osmeridae* spp). The high abundance of gadids in declining regions may be partially responsible for the shorter trip durations observed. Pinnipeds are probably opportunistic feeders (Geraci, 1975). It is therefore unlikely that they would forego large quantities of pollock to search for less available fish, even if gadids are inferior in quality. If a diet is composed primarily of these lean fish, it could also be that the sea lions lack the energy to undertake long foraging trips (Milette, 1999). Once again, lack of evidence for nutritional stress in the behaviors of mothers and pups may also be evidence that these cohorts are healthy. This further suggests that the juvenile cohort should be examined more thoroughly.

Table 2. Proportion of Steller sea lion scats and stomach contents containing five prey categories during the summer months in the declining Kodiak Island region in the 1970s, 1980s and 1990s (Merrick *et al.*, 1997). (Gadids = Walleye pollock, Pacific cod, Pacific hake; Small schooling fish = capelin, Pacific herring, eulachon and Pacific sand lance; Flatfish = arrowtooth flounder, rock sole).

	Gadids (%)	Salmon (%)	Small schooling fish (%)	Cephalopods (%)	Flatfish (%)
1990-1993	85.2	18.5	18.5	11.1	13.00
1985-1986	60.0	20.0	20	20	5.0
1976-1978	32.1	17.9	60.7	0.0	0.0

3. The Question of Quantity versus Quality

Prior to the major Steller sea lion population decline, the available diet information suggests that sea lions ate primarily small forage fish such as herring. Scat and stomach content analysis in the Kodiak Island area in the 1970s revealed a summer diet consisting primarily of herring, as well as smaller amounts of gadids and salmon. During the decline, however, their primary prey became gadids such as pollock and cod (60%), supplemented with forage fish, cephalopods, salmon and flatfish (Table 2). This noticeable switch in prey composition during the population decline involves a reduced quality of prey.

The question of nutritional quality versus quantity of prey is a complex component of the nutritional stress hypothesis. Steller sea lions declined in the Gulf of Alaska as forage fish stocks declined and gadid stocks increased over 20 years. The newly abundant stocks of prey (gadids) may be of inferior quality to the reduced stocks (forage fish). Alternatively, there may be a shortage of the appropriate smaller size classes of gadids required by marine mammals. Adult pollock and other gadids prey on juvenile pollock and thus compete with Steller sea lions for them, as do a whole host of other fish, bird and mammalian groups. Such competitive interaction may be important, but it does not negate the very real differences in nutritional quality of different prey types consumed by Steller sea lions, namely the quality of small schooling fish compared to gadids.

3.1 Quality of Pre-decline Steller Sea Lion Prey

The diet composition of Steller sea lions in the Aleutian Islands and the Gulf of Alaska prior to the population decline consisted primarily of small schooling fish that were dominated by Pacific herring. Herring are seasonal feeders that build up large fat reserves to overwinter without feeding. Thus their body composition fluctuates substantially throughout the year (Perez, 1994). Generally, herring is referred to as a "fatty" fish (oil 5-15%, protein 15-20%) (Stansby, 1969), with an average body fat content of approximately 12.8% (range from 2.2% to 24%) (Alverson, 1992; Stansby, 1976; Walford & Wilber, 1955). The energetic density of herring has been estimated from 7.28 to 9.86 kJ/g of dry mass, but again, it must be emphasized that this energy will vary among seasons, age classes, reproductive status and locations (Perez, 1994; Rosen & Trites, 1999).

Herring has been used in laboratory studies to test the comparative nutritional quality of different fish species, and has always emerged as an excellent source of protein and fat that promotes rapid growth without noticeable ill side effects (Lawson *et al.*, 1997a; Privett *et al.*, 1960; Rosen & Trites, 1997; Rosen & Trites, 2000a; Rosen & Trites, 2000b). For example, during two studies of approximately three week feeding trials using herring, juvenile Steller sea lions gained an average of 0.1-0.3 kg/day (Rosen & Trites, 1999; Rosen & Trites, 2000b). Digestibility of herring is higher than that of other species of fish. For example, in captive ringed seals (*Phoca hispida*), digestibility of herring was 94% versus lower values for Arctic cod (*Boreogadus saida*) (88%), capelin (87%) and redfish (*Sebastes* spp.) (83%) (Lawson *et al.*, 1997a). Herring is one of the most commonly used foods in marine aquariums, and with supplementation of the appropriate vitamins and minerals, has proven to be a successful diet for captive pinnipeds (Geraci, 1975).

3.2 The Junk Food Hypothesis

Gadids have been the primary prey species for Steller sea lions, as well as for many other marine mammals and birds since the early 1980s. The concurrent decline of these bird and mammal species has raised questions about the nutritional quality of gadids.

Gadids are a large family of fish including many Alaskan species such as walleye pollock, Pacific cod (*Gadus macrocephalus*), saffron cod (*Eleginus gracilis*), Pacific tomcod (*Microgadus proximus*), whiting (*Merlangius merlangus*), haddock (*Melanogrammus aeglefinus*) and hake (*Urophycis* spp); many of which are eaten by sea lions (Calkins & Pitcher, 1982). Gadids are generally referred to as "non-fatty" or "lean" fish (oil < 5%, protein 15-20%) with reported energy densities ranging from 4.35 to 4.94 (Table 3) (Rosen & Trites, 2000a; Stansby, 1969).

Composition analyses (Table 3) show that the primary difference between gadids and herring is the fat content, which determines the amount of energy available to sea lions. Energy densities show gadids contain only 70-80% of the caloric content of herring. If energy content were the only difference between the species, and stock sizes were adequate, sea lions would be expected to increase their food intake to fully meet their energetic requirements. However, the ecological costs of increasing food intake to make up for low calorie food may include more time and energy spent foraging, longer absences from pups, and higher metabolic requirements to search for prey. Additionally, the more intensely Steller sea lion diets have concentrated on pollock and gadids, the greater the rate of their decline (Merrick, 1995), insinuating that merely increasing gadid intake cannot make up for their low quality.

Observations such as those noted above have led to formulation of the "junk food hypothesis" which states that the nutritional stress experienced by Steller sea lions in Alaska is a result of switching their diet from high quality, fatty fish to low quality, non-fatty fish such as pollock. This switch in quality is hypothesized to be responsible for the decreased body condition of Steller sea lions as indicated by lengths, girths and weights

Table 3. Partial composition analyses and energy densities of common Alaskan gadids and herring (Perez, 1994; Walford & Wilber, 1955).

	Oil (%)	Protein (%)	Energy Density (kcal/g dry mass)
Pollock	0.8	20	4.94
Cod	0.4	17	4.54
Whiting	0.4	17	not available
Haddock	0.3	18	not available
Herring	11	19	6.21

of animals sampled, rather than fish abundance. This theory is consistent with stock estimates of increasing gadid biomass during the sea lion decline (Alverson, 1992) as well as the lack of evidence of severely emaciated animals such as occurred during the 1983 El Nino, when food availability was scarce. Many laboratory experiments have examined parameters such as the digestive efficiency, assimilation efficiency and heat increment of feeding of sea lions on pollock diets, along with other parameters to test for the inferior quality of gadids for marine mammals and birds.

3.2.1 Quality of Present Day Prey of Steller Sea Lions in Alaska

Pollock and other gadids are undoubtedly lean fish, but additional qualities also render them less nutritious for pinnipeds. When juvenile harp seals (*Phoca groenlandica*) were switched from a diet of Atlantic herring to Atlantic pollock, the seals' body fat content declined by 32% over 30 days while their body protein increased in proportion to protein intake (Kirsch, Iverson & Bowen, 2000). This loss of body fat occurred despite normal food intakes of approximately 6.5 kg/d, and reflected a change in body composition (reduced fat and increased protein) versus body mass. This implies that marine mammals may not be able to maintain energy reserves on pollock diets despite large intakes. Reductions in body fat caused by eating large amounts of pollock could be detrimental to animals residing in cold environments and subject to periodic fasts between foraging bouts. It could also be detrimental to nursing mothers that require fat stores to produce milk for their young. Concurrent increases in body protein content could be energetically expensive as protein is metabolically active and increases an animal's caloric requirements.

When switched from diets of herring to pollock, six young captive Steller sea lions lost approximately 0.6 kg/day during short periods of 11-23 days (Rosen & Trites, 2000b). Despite the fact that these animals were allowed to eat as much pollock as they wanted, they did not increase their energetic intake sufficiently to compensate for the low caloric content of pollock. Failure to increase their food intake was puzzling and might be related to factors that determine satiation. Although these animals were able to eat as much as they wanted at feeding times, it is possible that the volume of food required to meet their energetic needs may have been too large to eat in two or three meals. More regular unlimited feeding might have resulted in increased food intake. A similar result was found when feeding these sea lions low-fat squid. Their intake was approximately 7 kg/d, regardless of diet and nutritional quality, again indicating satiation as a factor controlling food intake (Rosen & Trites, 1999). As expected, the sea lions' loss in body weight was accompanied by suppression of mass specific resting metabolic rate, indicating a fasting or nutritionally stressed state.

Earlier studies concluded that the energy required to digest a meal of pollock (the heat increment of feeding, HIF) was higher than that required to digest a similar size meal of herring (15.7 % versus 11.9% of gross energy intake, respectively) (Rosen & Trites, 1997). Additionally, they found that larger meals were more energetically expensive to consume than smaller meals, which would be costly to an animal attempting to eat more food to compensate for low fat content. The loss of body mass in Steller sea lions eating pollock is therefore attributable to many factors including the lower energy content of pollock, a higher HIF of pollock than herring, and the need to compensate for low energy values of pollock. This means that a Steller sea lion would have to consume 35-80% more pollock than herring to obtain an equal number of calories (Rosen & Trites, 2000b).

Negative responses to switching diets from high-energy forage fish (clupeids such as herring and sprat – *Sprattus sprattus*) to gadids have also been documented in wild harbor seals in Scotland. Blood leukocyte counts were significantly elevated during years when herring and sprat occurrence in the diet was low (1989-1992) compared to years when they were the major dietary species (1987-1989 & 1993-1995) (Thompson *et al.*, 1997). This could be due to immuno-suppression because of differences in prey contaminant or nutrient levels, or it could be due to differences in water quality between years and between foraging sites. More notably, when the seals switched to a primarily gadid diet, there was evidence of widespread macrocytic anemia thought to be related to differences in the nutritional quality of the prey. Iron levels in white flesh fish such as gadids are lower than in darker flesh fish (Geraci, 1975), which might explain the anemic conditions.

Complications in iron absorption have been reported in mink that were fed gadids, such as hake and whiting. This results in a condition known as "cotton-fur". This syndrome is characterized by animals that are often emaciated and smaller than their non-cotton fur counterparts and whose underfur is uncharacteristically light in color due to lack of pigmentation (Stout, Oldfield & Adair, 1960). In one study, inclusion of hake and whiting in mink diets resulted in reduced size of animals and fur depigmentation proportional to the level of inclusion of gadids in the diet (Stout *et al.*, 1960). Similarly, mink that were fed diets including 30% hake suffered from lower lifetime weight gain and possible impaired iron absorption as indicated by lower levels of stored iron in the spleen and liver (Rouvinen, Anderson & Alward, 1997).

Caution should be used when extrapolating results of iron deficiency and poor fur quality to wild animals. Only one of the above studies was conducted in the wild. Furthermore, impaired iron absorption in the captive studies may be a function of the hake having been frozen. When hake were either cooked or fed fresh and unfrozen, this cotton-fur disorder was less apparent if present at all (Costley, 1970). The factor causing cotton-fur is hypothesized to be formaldehyde, a secondary by-product of lipid oxidation, and not present in fresh fish nor applicable to feeding in the wild.

Alaskan pollock protein fed to rats resulted in alteration and partial destruction of kidney and liver tissues, the extent of which was related to the amount of protein used in the diet (Gulich, Onoprienko & Sokolova, 1990). However, it is not known whether the toxicity was due to the protein itself, or due to by-products (acetiline amino acids) of the processing methodology.

Factors other than body composition and vitamin and mineral content can affect the nutritional value of a diet. The digestive efficiency of diets may reflect "biologically available" nutrition. Juvenile Steller sea lions fed different diets of pollock, herring, squid and salmon revealed differences in digestive efficiency (percentage of prey energy retained) (Rosen & Trites, 2000a). The digestive efficiency appeared to have some relationship with energy density, being greatest for herring (95.4%), then pollock (93.9%) and salmon (93.4%), and finally squid (90.4%).

Captive harp seals fed diets of Atlantic cod (*Gadus morhua*), Arctic cod, Greenland halibut (*Reinhardtius hippoglossoides*), Atlantic herring and capelin (*Mallotus villosus*) showed the lowest digestive efficiencies while consuming the low-fat gadids - Atlantic and Arctic cod (93.5% for both versus 94.7%, 95.7% and 96.6% for halibut, capelin and herring, respectively) (Lawson, Miller & Noseworthy, 1997b). Similar relationships between digestive efficiencies and energy content of the diet were found within kittiwakes and guillemots fed capelin or cod (Brekke & Gabrielsen, 1994). This could potentially have contributed to the decline of marine birds that switched their prey from small forage fish to gadids as well. Dry-matter digestibility of sea lion diets of pollock and herring, defined as the change in dry-matter concentration between food items and feces, was lowest for pollock diets (86.5%), due to the high proportion of bony material in pollock (Rosen & Trites, 2000a).

All of these results support the theory that pollock is less nutritious than herring, and that switching from a high quality, diverse diet including herring to one predominantly of pollock could place marine mammals under nutritional stress.

4. Summary

The Steller sea lions in central and western Alaska have undergone a dramatic population decline in the last thirty years. The nutritional stress hypothesis holds that this decline was due to reduced availability of suitable prey (Rosen & Trites, 2000b). The decline may have initially been due to reduced abundance of several important species of high-quality fish preyed upon by the sea lions, such as herring and other small forage fish. The fish stocks that seemed to replace the disappearing forage fish in the ecosystem and in the diets of Steller sea lions were predominantly gadids and flatfish (Trites *et al.*, 1999). If the nutritional value of all fish were equal, the newly abundant stocks of gadids and flatfish should have been able to support the reduced numbers of sea lions. However, the continued decline of Steller sea lions in central and western Alaska supports the view that these gadids are not as nutritious as the prey that were present prior to the decline, and that marine mammals are unable to flourish on a low fat/low calorie fish.

Evidence to support the nutritional stress hypothesis is abundant. Nutritional stress in mammals can result in reduced body size, reduced productivity, reduced survival of pups and juveniles, and modified behavior and blood chemistry. Currently, sea lions in Alaska are smaller in length, girth and weight compared to animals prior to the decline (Calkins & Goodwin, 1988). This is most evident in the juvenile cohort (ages 1 – 3 years), which are believed to be more susceptible to nutritional stress than adults or nursing pups.

There is evidence of reduced productivity during the decline, as measured by pup counts and the incidence of failed pregnancies (Calkins & Goodwin, 1988). Lactating females were also less likely to be pregnant than non-lactating females during the decline, indicating that the energetic stress of nursing while being pregnant with another pup may have prevented some females from giving birth each year (Pitcher, Calkins & Pendleton, 1998).

Testing blood for signs of nutritional stress has yielded inconclusive results. Testing for metabolic parameters such as glucose, fatty acid and ketone body levels show no signs of nutritional stress, but testing for haptoglobin and hemoglobin show signs of anemia and increased immune system activity (Bradley *et al.*, 1993; Calkins & Goodwin, 1998; Rea *et al.*, 1998; Zenteno-Savin *et al.*, 1996).

Behavioral studies have not shown evidence of nutritional stress in the Steller sea lions in Alaska. Lactating Steller sea lions in the area of population decline do not seem to increase the time they spend foraging, the distance they travel to find food, or the time they spend nurturing their pups (Merrick *et al.,* 1997; Milette, 1999). All of these changes should have been observed if overall food availability was low.

The nutritional stress hypothesis is supported by studies that have examined the quality of the fish that were eaten by sea lions before the decline (herring and small schooling fish) and during the decline (gadids). Pinnipeds that feed on gadids would require ~35-80% more food than those eating herring due to the low fat content and energy content of gadids (Rosen & Trites, 2000b). The lower energy content of their prey rather than the biomass of prey available to them might effectively set a lower carrying capacity for Steller sea lions. Gadid biomass is high in the Gulf of Alaska and Bering Sea, but gadids are less nutritious than small forage fishes for pinnipeds. Steller sea lions require more energy to digest pollock than they do to digest a similar sized meal of herring. They also incur greater energetic costs to eat larger fish than they do to eat smaller fish (Rosen & Trites, 1997, 2000a). Possible toxic effects of gadids in the diets of pinnipeds are still under investigation, and may explain symptoms of anemia in pinnipeds eating pollock (Calkins & Goodwin, 1988; Gulich *et al.*, 1990).

In conclusion, there is a considerable, growing body of evidence supporting the nutritional stress hypothesis as the major contributor to the Steller sea lion decline in Alaska. Support for alternative hypotheses is weak or non-existent (e.g., disease, predation, competition with fisheries, incidental catch and others), leaving nutritional stress as the most widely accepted and tested theory to explain the decline of Steller sea lions in Alaska.

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AGENDA C-5
DECEMBER 2000
SUPPLEMENTAL

A Review of the Effects of Regime Shifts on the Production Domains in the Eastern North Pacific Ocean

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The intent of this review is to identify the timing of regime shifts in the north Pacific Ocean and to characterize the nature of the biological responses, from primary producers through to the top predators in the food chain. The available data indicate that large-scale, low frequency variations occurred in climatic and oceanic conditions in 1925, 1947, 1977 and 1989. They also indicate that these changes occurred abruptly and were not random variations. Changes in atmospheric pressure can alter wind patterns that affect oceanic circulation and physical properties such as salinity and depth of the thermocline. This in turn affects primary and secondary production. Regime shifts can have opposite affects on species living in different domains, or can affect different species living within a single domain in opposite ways. The effects of climatic forcing on fish and marine mammals are not easy to predict, and may indirectly affect these populations through changes in the distribution and abundance of predators and prey. Direct effects of regime shifts on marine ecosystems are manifested more quickly than indirect responses. Natural variability in the productivity of fish stocks in association with climate indicates that new approaches to managing fisheries should incorporate climatic as well as fisheries effects.

Contents

1. The Regime Concept

Isaacs (1975) introduced fishery scientists to the concept of 'locked in" trends in climatic, oceanic and biological systems (MacCall, 1996; Beamish et al., 2000). He called these persistent trends *regimes*. Regimes have been defined as multiyear periods of linked recruitment patterns in fish populations or as stable conditions in physical data series (Beamish et al., 1999). Concurrent (and sometimes abrupt) changes in these biological and physical variables indicate a *regime shift*. These natural patterns of variability raise questions about the biological basis of sustainability of fisheries (Beamish, 1995), and are leading ecologists away from a single, steady state view of ecosystems to one that recognizes that ecosystems fluctuate because of internal and external sources of variability (e.g., Steele, 1996; Trites et al., 1999).

2. Climate/Ocean Variability

The basic state of the atmosphere-ocean climate system over the north Pacific Ocean shifted abruptly in the late 1970's (Ebbesmeyer, 1991; Graham, 1994). Atmospheric circulation changed throughout the troposphere (Trenberth, 1990), and the Aleutian Low pressure system deepened (Miller et al, 1994) and shifted eastward (Trenberth, 1990). This in turn advected warm, moist air over Alaska and colder air over the north Pacific. Concurrently, sea surface temperatures cooled in the central Pacific and warmed along the west coast of North America (Miller et al, 1994). Sea ice decreased in the Bering Sea (Manak and Mysak, 1987) and changes were observed in the surface wind stress (Trenberth, 1991) that would have affected ocean currents in the north Pacific.

Indices[1] of climate-ocean conditions indicate that a synchronous change occurred in the north Pacific in 1977. Since then, there has been a tendency for more frequent El Niño and fewer La Nina events (Trenberth and Hoar, 1996). Such large-scale changes suggest that an as yet unidentified common, global event may be responsible for the shift (Beamish et al., 2000).

The climatic shift noted in the late 1970's was not the first time such a change had occurred. In fact, it appears to have occurred three other times in the 20th century. Mantua et al. (1997) and Minobe (1997) identified shifts in the atmosphere-ocean climate record in 1925, 1947 and 1977. Overland (1999) and Beamish et al. (1999) also report that a fourth shift occurred in 1989.

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[1] Our review is limited to the most common indices that characterize climate and ocean conditions over the north Pacific Ocean. Other indices developed include the Pacific Circulation Index (PCI) (King et al., 1998), the Northern Hemisphere surface (land and ocean) temperatures (NHST) (Jones, 1994), and the length of day (LOD) (Stephenson and Morrison, 1995) which demonstrates changes in the earth's rotational speed. Others have been developed for the Atlantic Ocean, these include the North Atlantic Oscillation Index (NAOI) (Walker and Bliss, 1932) and the Atmospheric Circulation Index (ACI) for the Atlantic basin (Beamish et al., 1999).

The climatic and biological events noted in the north Pacific in the mid 1970s and at other times this century have been quantified by a number of different indices. Four of the more commonly cited ones are 1) the Southern Oscillation Index (SOI), 2) the Aleutian Low Pressure Index (ALPI), 3) the North Pacific Index (NPI), and 4) the Pacific Decadal Oscillation (PDO). A comprehensive review of climate indices may be found in Beamish et al. (2000).

2.1 *Southern Oscillation Index*

The Southern Oscillation Index (SOI) describes the oscillation of air masses between the eastern and western tropical regions of the Pacific Ocean (Walker, 1924). It is commonly (but not always) linked with El Niño events and is termed the El Niño – Southern Oscillation (ENSO). This index measures the difference in sea level atmospheric pressure between Tahiti and Darwin, Australia (Beamish et al, 2000). Anomalously high pressure at Darwin (negative SOI) results in weakened westerly winds and warmer sea temperatures (El Niño) in the eastern Pacific Ocean (Trenberth and Hoar, 1996). The converse (intense westerlies, lower sea level pressure in the west, positive SOI) occurs in a La Nina event.

Figure 1 shows average monthly SOI oscillating between the negative (El Niño) and positive (La Nina) states. It also shows that a major change occurred after the 1977 El Niño when the familiar oscillations between positive and negative were replaced by persistent negative (El Niño) conditions. Since 1990, more exceptionally intense and frequent El Niño events have occurred than at any other time in the past 113 years of records (Trenberth and Hoar, 1996).

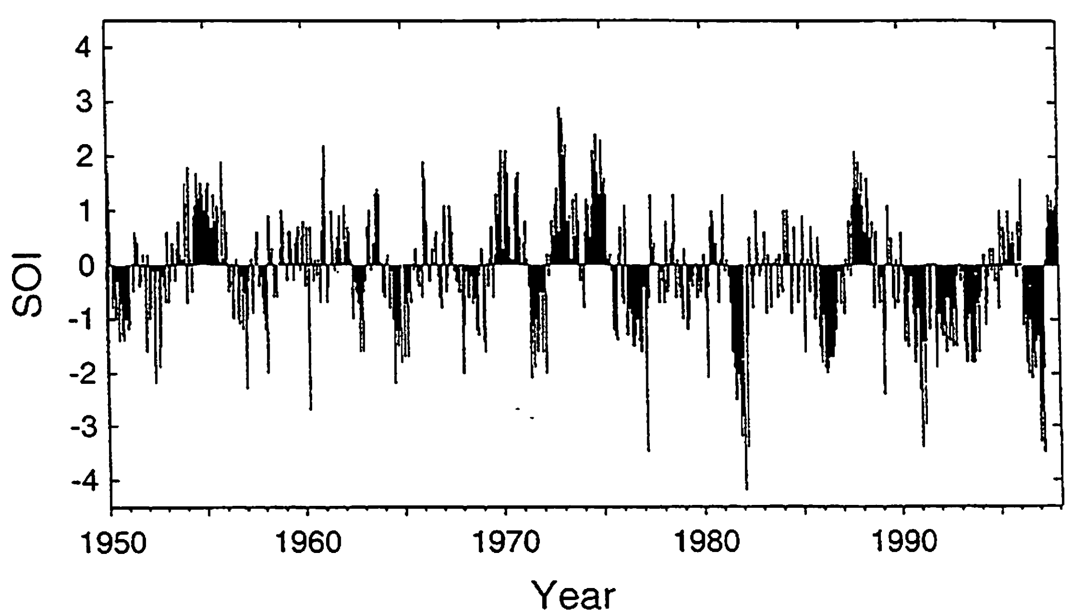

Figure 1. The monthly Southern Oscillation Index (SOI) January 1950-December 1998 provided by the National Oceanic and Atmospheric Association (NOAA) as it appears in Beamish et al. (2000).

2.2 Aleutian Low Pressure Index and the North Pacific Index

The Aleutian Low Pressure Index (ALPI) (Beamish and Bouillon, 1993) and the North Pacific Index (NPI) (Trenberth and Hurrell, 1995) are both measures of the intensity of the Aleutian Low atmospheric pressure system, which affects the strength of winter storms. The ALPI measures the area of low pressure while the NPI is the area weighted mean sea level pressure over the region 30°N to 65°N, 160°E to 140°W (Trenberth and Hurrell, 1995). The ALPI and the NPI are negatively correlated (Beamish et al. 2000), which means that a large Aleutian Low (positive ALPI) will have very low pressure (negative NPI). From 1947-1976, the ALPI was generally negative (i.e., the Aleutian Lows were smaller), while from 1977-1988, the ALPI was positive (reflecting a period of more intense Aleutian Lows) (Figure 2). The intense period ended after 1989. These decadal variations are also evident in the NPI (Figure 3).

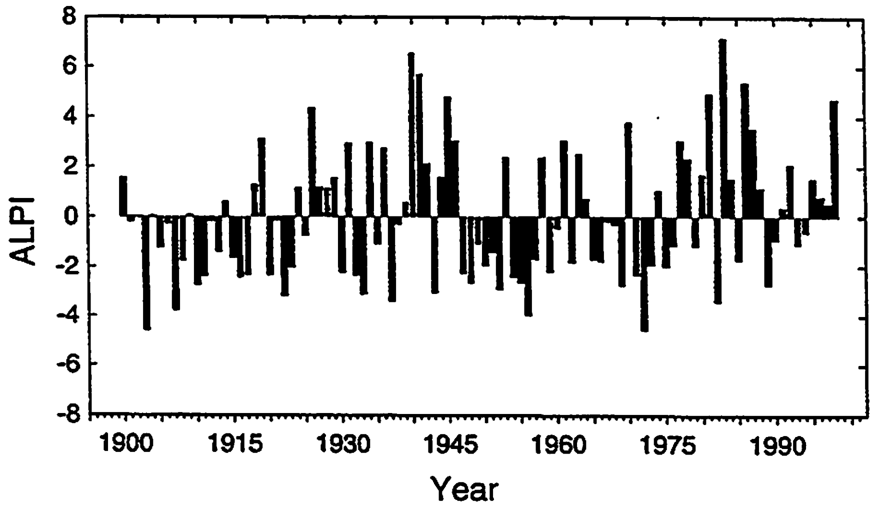

Figure 2. The Aleutian Low Pressure Index (ALPI) from Beamish et al. (2000).

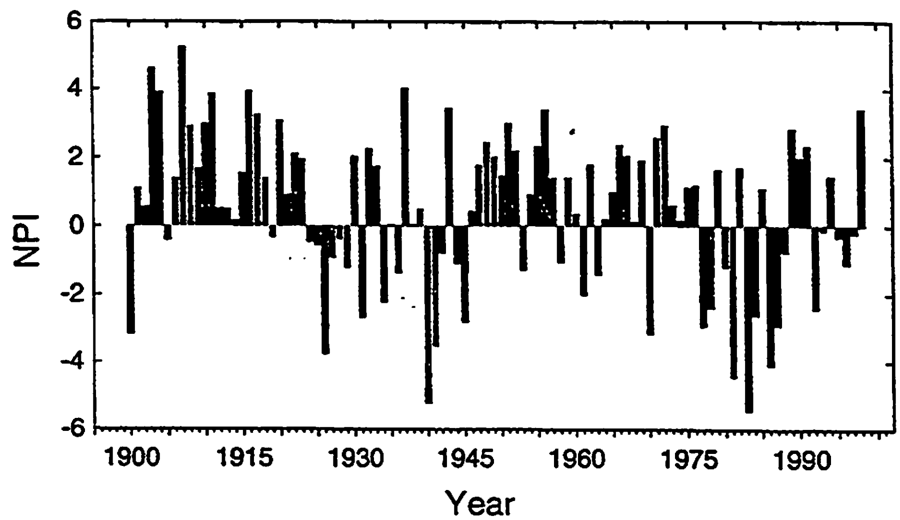

Figure 3. The North Pacific Index (NPI) of Trenberth and Hurrell (1995) from Beamish et al. (2000).

2.3 Pacific Decadal Oscillation

Mantua et al. (1997) examined a broad collection of data including sea surface temperatures (SST) and sea level pressure (SLP) from the tropical, extra tropical and coastal north Pacific. They also considered land surface temperature during winter and precipitation over North America, as well as North American river discharge rates and winter atmospheric pressure. Mantua et al. identified an interdecadal oscillation between phases (regimes) in the records they compiled. They called this decadal scale variability in the North Pacific climate-ocean environment the Pacific (inter) Decadal Oscillation (PDO). Like the NPI, ALPI, and SOI, the PDO has positive and negative phases. When the PDO is positive, a cooling occurs in the central North Pacific and a warming occurs along the coast of Canada. When it is negative there is a warming in the central North Pacific and cooling along the Canadian coast. Mantua et al. (1997) noted that the PDO was positive between 1925 and 1946, negative between 1947 and 1976, and positive since 1977 (Figure 4). They did not identify a significant change in 1989 (Beamish et al. 2000).

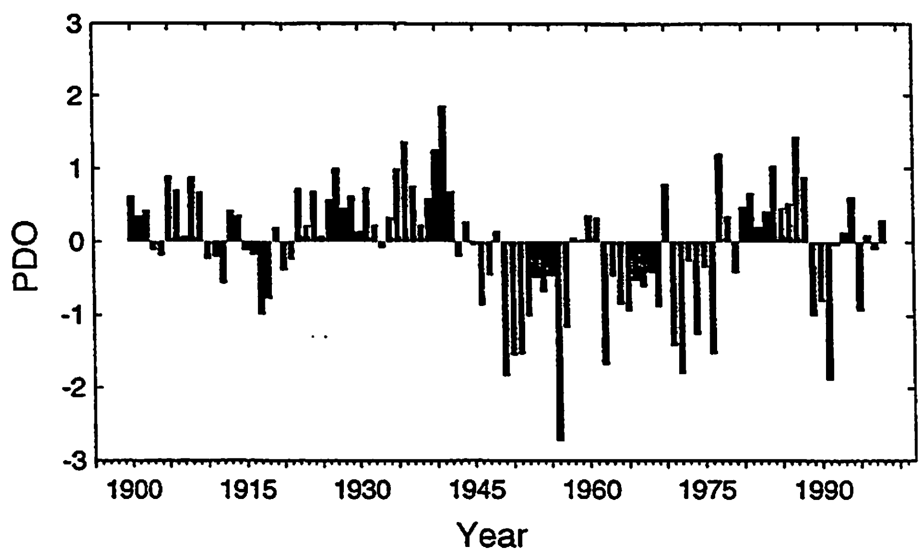

Figure 4. The Pacific Decadal Oscillation of Mantua et al. (1997) from Beamish et al. (2000).

3. Detecting a Change in a Time Series

Although the decadal variations in these four major indices of the north Pacific appear to be simple oscillations, Beamish et al. (1999) point out that there is no reason to assume regime shifts are cyclic. They point out, for example, that the weakening of the Aleutian Low after 1989 resulted in a different dominant wind direction than existed prior to 1977. The most common technique used to detect significant changes in regime shift time series (e.g. Mantua et al., 1997; Noakes, 1986) is called intervention analysis (Box and Tiao, 1975). A Box-Jenkins autoregressive integrated moving average (ARIMA) (Box and Jenkins, 1976) model is first fitted to the data to account for any autocorrelation (which is contained in most environmental data) in the time series. Interventions in the form of steps are then introduced to the model and their significance is tested as a change in the mean. The test is analogous to a two sample *t*-test (Mantua et al., 1997).

4. The Response of the North Pacific Production Domains

The dominant feature in the Central Subarctic Domain (Central Gulf of Alaska) (Figure 5) is the Alaska Gyre which rotates in a counter-clockwise (cyclonic) direction (Ware and McFarlane, 1989). This circulation results in divergence (upwelling) in the core of the gyre, which is believed to be the reason this domain is relatively productive (Reid, 1962). An intensification of winds might improve productivity by causing the gyre to accelerate and result in increased divergence and upwelling of nutrient rich water at the core (Brodeur and Ware, 1992, Reid, 1962).

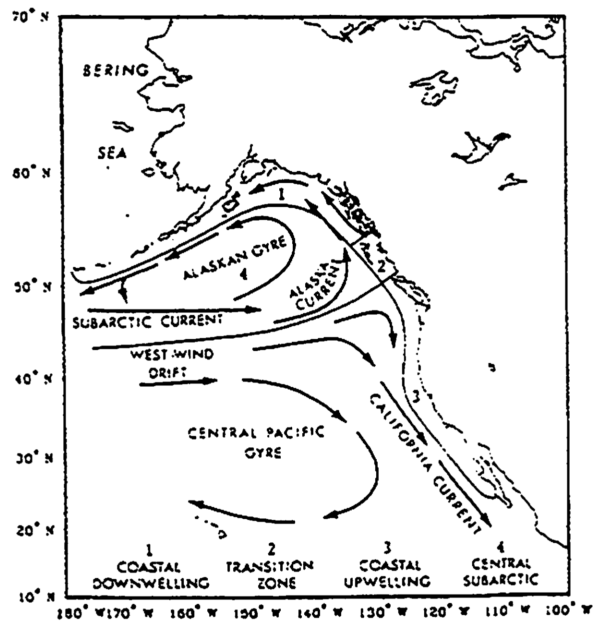

Figure 5. Prevailing ocean currents and the four major domains defined by Ware and McFarlane (1989).

McFarlane and Beamish (1992) found the biomass of copepods increased in 1976-77 in the Alaska Gyre, coincident with cooling of the central north Pacific and an intensification of the Aleutian Low (an index of winter wind stress). Brodeur and Ware (1992) examined zooplankton collections from the subarctic Pacific and found that the biomass more than doubled between the late 1950s and the 1980s. They also found a positive relationship between winter wind intensity and summer zooplankton biomass.

Venrick et al. (1987) showed that in the central north Pacific (just north of Hawaii) the total chlorophyll *a* (a proxy for phytoplankton production) nearly doubled around the time of the 1977 regime shift. Venrick (1994) subsequently showed that this was due to a deepening of the mixed layer, which resulted in increased phytoplankton production in deep water. Polovina et al. (1995) provided supporting evidence by demonstrating that concurrent with the intensification of the Aleutian Low and regime shift of 1977, there was a deepening of the mixed layer in the subtropical domain near the Hawaiian Islands, while the mixed layer became 20-30% shallower in the Gulf of Alaska. Polovina et al. also noted that primary and secondary production could be expected to improve in the two areas by increasing the exposure of phytoplankton to light in the Gulf of Alaska and by mixing deeper, nutrient rich water into the euphotic zone in the subtropical North Pacific.

The nature of the response to environmental variation is not the same for all production domains of the northeast Pacific. For example, Roemmich and McGowan (1995) found that the biomass of zooplankton in the Coastal Upwelling Domain (California Current) (Figure 5) exhibited an opposite response to that in the Gulf of Alaska and decreased by approximately 80% between the early 1950s and 1990s. At the same time, the surface layer also warmed in the upwelling domain (MacCall, 1996). It was unclear whether zooplankton declined gradually or rapidly. Roemmich and McGowan noted that the decline of zooplankton may be attributable to coastal warming associated with the 1977 regime shift that increased stratification and reduced upwelling of nutrient rich water in the California Current. They also noted that it might be the result of a climate-induced change in ocean circulation that might bring warmer water into the area and limit the supply of nutrients and/or advect zooplankton away from the coast.

Hollowed and Wooster (1992) noted that there appear to be two environmental states in the North Pacific Ocean. The first is strong circulation in the Alaska gyre (strong Aleutian Low) and weak upwelling along the west coast of North America. This state is specific to warm eras and is commonly initiated by El Niño events. In the second state, there is weak oceanic circulation in the Gulf of Alaska and strong upwelling along the coast. This is characteristic of cool eras (Figure 6). Gargett (1997) proposed a mechanism to explain the apparent opposite response to decadal scale climate change exhibited by the northern and southern production domains. In the subarctic north Pacific, the stability of the water column is determined mostly by salinity and light levels that limit primary productivity (Polovina et al. 1995). Turbulent mixing reduces stability. In the subtropical gyre, stability is determined primarily by temperature, and primary productivity is limited by nutrients, while water column stability is reduced by coastal upwelling.

The Aleutian Low (the winter low pressure system over the North Pacific Ocean) develops in the fall of each year and breaks down in the spring of the following year (Beamish and Bouillon, 1995). Onset of the Aleutian Low results in increased precipitation in the subarctic north Pacific. This freshwater input has a strong, stabilizing effect on oceanographic conditions. Intensification of the Aleutian Low leads to winds that are unfavorable for upwelling further south along the coast of North America. This also leads to increased water column stability. Although the water column stability might vary in phase between the two regions, the effects on production would be expected to differ. In the Gulf of Alaska, increased stability means that the phytoplankton can be maintained in the euphotic zone for longer periods of time, thereby increasing primary production. On the other hand, off California, increased stability and less upwelling results in a decreased nutrient supply. Since the phytoplankton in this area are limited by nutrients and not light, primary production (and by inference, secondary production) can be expected to decline.

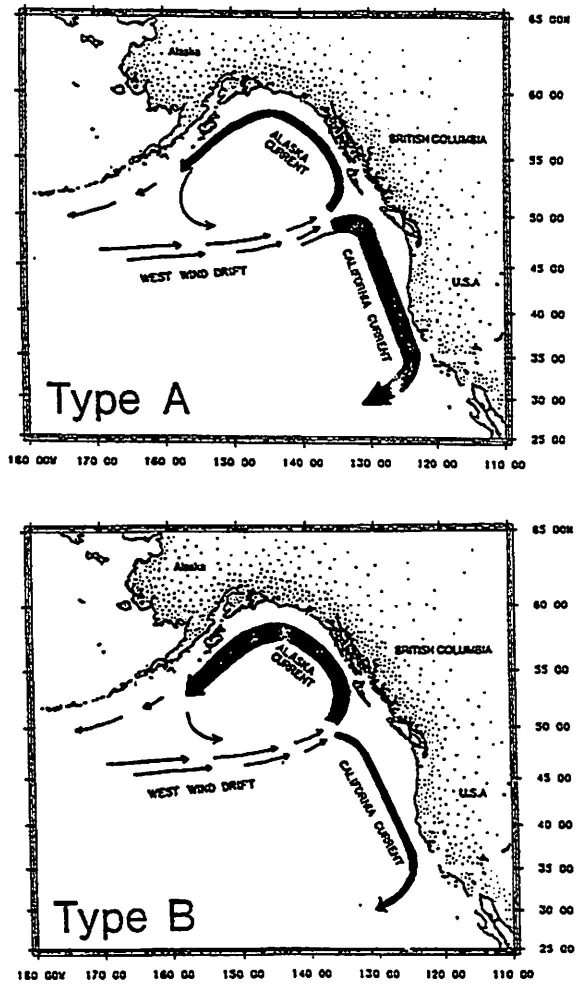

Figure 6. Circulation patterns associated with Type A and Type B conditions from Hollowed and Wooster (1992).

The Bering Sea reflects large-scale ocean variations, but the timing of the events is not necessarily synchronous with those further south (Wooster and Hollowed, 1995). There are indications of a cool era from about 1965 to 1978, and of a warm period beginning in 1978 (Wooster and Hollowed, 1995). Niebauer (1988) used sea ice as an indicator of Bering Sea conditions and noted a significant decrease in the winter ice cover after 1977. Variability in the climate-ocean conditions in the Bering Sea is related to ENSO and the mechanism that connects the two appears to be the Aleutian Low.

Sugimoto and Tadokoro (1997) examined short and long-term variations in summer plankton biomass in the entire subarctic Pacific and in the Bering Sea during 1954-1994. They found that the zooplankton biomass and chlorophyll concentration in the eastern Bering Sea and eastern subarctic Pacific increased in the mid-1960s and remained high until the end of the 1980s. They demonstrate a significant positive correlation between summer plankton biomass and winter wind speed in the eastern Bering Sea. They also found that the zooplankton biomass and chlorophyll concentration during the mid 1960s to early 1970s were higher than those in the preceding and following decades for the central and western subarctic Pacific. The values declined in the late 1980s.

5. Fish and Climate Change

5.1 Coastal Upwelling Domain

Long-term variability has persisted in fish populations for centuries. Soutar and Isaacs (1974) analyzed fish scale depositions (a proxy for fish abundance) in the anaerobic sediments of the Santa Barbara Basin and found evidence of large, natural, long-term fluctuations in the abundance of pelagic fishes, including Pacific sardine (*Sardinops sagax*) and northern anchovy (*Engraulis mordax*). Baumgartner et al. (1992) examined these scale depositions over a much longer time period, spanning the last 1700 years, and found persistent variability in both sardine and anchovy deposition that showed peaks approximately every 60 years. Ware (1995) identified a peak in the range of 50-75 years. MacCall (1996) examined coastal pelagic fish abundances throughout the 1900s in the California Current ecosystem and found low frequency fluctuations in the dominant species that are cyclic and related to cold and warm periods that occur every 50 to 70 years. Interestingly, the sequence appears to alternate between piscivores (bonito and Pacific mackerel) and planktivores (sardine and anchovy).

Kawasaki (1991) examined catches from three sardine populations in the Pacific Ocean and the European pilchard in the Atlantic Ocean from 1910 to the late 1980s, and found simultaneous changes in their abundance. In the same study, Kawasaki examined Pacific and Atlantic herring and showed that their abundance also fluctuated synchronously, although with a different phase than the sardines. McFarlane and Beamish (1999) note that sardines were the focus of the largest fishery in British Columbia from the 1920s to the mid-1940s, after which they disappeared. This collapse occurred simultaneously off the coast of Canada and the United States and has traditionally been touted as a prime example of overfishing (Hilborn and Walters, 1992).

The trends in abundance of sardine populations off Japan, California and Chile are synchronous - the collapse of the sardine stocks off the United States and Canada was concurrent with the collapse of the Japanese stocks (Kawasaki and Omori, 1988). This synchrony is strong evidence that the reason for the collapse had more to do with changes in ocean habitat than with fishing (McFarlane and Beamish, 1999). In the early 1980s, the sardine population off the coast of California began to recover and has been steadily increasing (Barnes et al., 1992). A recovery in British Columbia began in 1992 when sardines were reported in catches of Pacific hake (*Merluccius productus*) (McFarlane and Beamish, 1999). Furthermore, the behaviour of sardines changed. Their distribution shifted north, they moved into the Strait of Georgia, and they began spawning off the west coast of Vancouver Island (McFarlane and Beamish, 1999).

In addition to being a potentially important fishery resource, sardines may be important competitors of other species. Schweigert (1995), for example, found a significant difference in the survival rate of Pacific herring (*Clupea pallasi*) off the west coast of Vancouver Island before and after the disappearance of sardines in 1950. He speculates that the large herring recruitments that occurred off the west coast of Vancouver Island (WCVI hereafter) in the late 1930s and early 1940s were due to reduced competition from declining sardine stocks.

Ware (1991) examined the WCVI herring stock and found that herring growth rates were negatively influenced by warm ocean conditions and the associated lower zooplankton biomass. Recruitment was inversely related to sea surface temperature. Ware and McFarlane (1995) have shown that the abundance of Pacific hake (the key predator) increases along with ocean temperatures off the WCVI. This results in increased predation pressure on herring.

Schweigert (1995) studied environmental effects of the long-term dynamics of two major southern herring stocks – the WCVI (offshore) and the Strait of Georgia (SOG hereafter). He found that the two stocks exhibited similar biomass trends throughout 1937-1992, although the levels remained stable throughout the time series for WCVI and declined slightly in SOG. Schweigert also found that recruitment of both stocks was correlated under average conditions but not for the strongest year classes, which are associated with unusual oceanographic conditions in the form of very strong ENSO events. A possible explanation for these results might lie in the different recruitment processes of the stocks.

The offshore stock of herring spawns in Barkley Canyon on the WCVI while the SOG stock spawns in the Strait. The juveniles of the SOG stock do not move out onto the shelf to feed until they are around 2 years old while the WCVI juveniles move offshore in their first year (Hourston and Haegele, 1980 in Schweigert, 1995). This may be an indication that recruitment is determined by the time the SOG herring move offshore. Interestingly, Schweigert (1995) was unable to identify a change in the survival rate of SOG herring prior to and after 1950 when the sardine had disappeared. Sardines were a buffer to hake predation only for the WCVI stock.

Zebdi and Collie (1995) examined herring recruitment variability in Sitka Sound from 1972-1990 and found a positive relationship with sea surface temperature. Based on the match-mismatch hypothesis of Cushing (1975), they concluded that warmer temperatures lead to earlier spawning, which benefits herring survival because early hatched larvae will find conditions (plankton blooms) favorable to their survival. It is also possible that the increase that occurred in zooplankton biomass in the Gulf of Alaska (Brodeur and Ware, 1992) during the same period may have improved overall feeding conditions for larvae. In the same study, Zebdi and Collie noted that herring recruitment was synchronous within, but not between production domains, and that the northern and southern stocks were out of phase by one year. In addition, the recruitment response to sea surface temperature differs between production domains. Sitka Sound herring respond positively to warmer temperatures while the southern stocks respond negatively to warmer temperatures.

McFarlane et al. (2000a) studied the effects of the 1989 regime shift on the SOG and WCVI ecosystems and found the two systems had opposite responses to the change. Offshore, the distribution of Pacific hake shifted north (McFarlane and Beamish, 1999) which resulted in a greater total abundance off the WCVI (McFarlane et al. 2000a). Hake traditionally spawned offshore along the Californian coast. However, they have spawned off the WCVI since 1994 (McFarlane et al. 2000b). McFarlane et al. (2000a) point out that herring stock off the WCVI declined throughout the 1990s, presumably due to the increased predation pressure by migratory hake. Herring and the resident stock of hake in the SOG are now at high levels of abundance because of the elimination of herring in the diet of hake, which is a consequence of a decline in mean body size of the SOG hake (McFarlane et al. 2000a). Hake smaller than 40cm feed primarily on euphausiids (Tanasichuk et al., 1991). McFarlane et al (2000a) suggest that herring had opposite responses in the two ecosystems due to differing ecosystem organizations after the regime shift.

The study by McFarlane et al. (2000a) is unusual in that it compares the response of two adjacent ecosystems within the same production domain. Much of the regime research has focused on comparing the response of stocks across production domains. For example, Hollowed and Wooster (1995) examined recruitment time series from 1950 to 1989 for six Pacific herring stocks, one northern anchovy stock and 16 groundfish stocks. They found parallel recruitment patterns in several groundfish species that related to switching between Type A and Type B conditions (Figure 6). They also found that strong year classes were infrequent in the northernmost regions (transitional and downwelling domains), while strong year classes were more common in the coastal upwelling domain. Most of the stocks that did exhibit strong year classes did so prior to 1977, but not after. Conversely, herring and widow rockfish in the Gulf of Alaska and off Prince Rupert had strong year classes only after 1977. This suggests that there was a shift in the production that differentially affected northern and southern stocks.

5.2 Pacific salmon

Pacific salmon (*Oncorhynchus spp.*) inhabit or pass through at least two production domains in their lifecycle. For example, Alaska pink (*O. gorbuscha*) and sockeye (*O. nerka*) spend most of their life in the Central Subarctic Domain (Ware and McFarlane, 1989), but on their seaward and return migrations they pass through the Coastal Downwelling Domain. Studies on the effects of climate on these species must therefore take into account oceanographic conditions in both areas (Hare and Francis, 1995). Fluctuations in Pacific salmon production trends, as they relate to large-scale climate variability, have been studied extensively (e.g. Beamish and Bouillon, 1993; Beamish and Bouillon, 1995; Francis and Hare, 1994; Hare and Francis, 1995; Mantua et al., 1997).

Evidence that large-scale salmon production is related to climate processes in the North Pacific is presented in the form of synchronous shifts in production among several species or stocks in response to a physical regime shift (Beamish and Bouillon, 1995; Hare and Francis, 1995; Hollowed and Wooster, 1995). There are indications that salmon abundance has varied with climate for centuries (Beamish et al., 1999) and that large-scale climate impacts occur in the oceanic, not the freshwater phase of the salmon lifecycle, at least for coho (*O. kisutch*) (Bradford, 1999). It should be noted that production has generally been estimated by catches or by abundance of recruits because salmon exploitation rates are high and are therefore considered to track abundance well (Beamish et al., 1999). However, use of these simple indices of production have been criticized because they can be confounded by changes in spawner abundance (Peterman et al. 1998).

Salmon production trends in Alaska are generally the opposite of those in the Pacific Northwest (Hare and Francis, 1995). Landings for the northern North Pacific and Alaskan salmon stocks were high in the 1930s and 1940s, low from the late 1940s through to the mid-1970s, and began to increase in the mid-1970s (Beamish and Bouillon, 1993; Hare and Francis, 1995). As the Alaskan landings increased in the 1970s, several North American west coast stocks, especially the Oregon coho salmon stock, began to decline (Pearcy, 1992). Beamish et al. (2000) point out that the 1989 regime shift was associated with some of the lowest catches in the history of the Canadian fishery and that this decline was most evident for the southern British Columbia stocks.

Two mechanisms have been proposed to explain the increased production in the northern stocks in the late 1970s. The first mechanism involves improved feeding conditions as a result of the regime shift. Beamish and Bouillon (1993) proposed that increased salmon productivity is linked with increased copepod production that is associated with periods of intense Aleutian Lows (McFarlane and Beamish, 1992). The other proposed mechanism relates to improved marine survival of migrating salmon in their last year at sea (Rogers, 1984). The improved survival is hypothesized to be a result of reduced vulnerability to predation by marine mammals because of an altered timing and route of migration due to warming of the surface waters in the Gulf of Alaska with the 1977 regime shift (Hare and Francis, 1995). Supporting evidence for both hypotheses is given by Brodeur and Ware (1995).

Brodeur and Ware (1995) compared catch data for five Pacific salmon species, two species of shark, three species of cephalopod and three nonsalmonid fishes (tuna, mackerel and pomfret) from the Gulf of Alaska for the late 1950s and 1980s. They showed that distribution patterns changed dramatically between the two periods. In the 1980s the distribution of most subarctic species was compressed to the northern and western side of the Gulf of Alaska. In addition, the catch rate for all species except Jack mackerel was substantially higher in the 1980s. The authors note that in their earlier study (Brodeur and Ware, 1992) they found a twofold increase in zooplankton biomass in the eastern subarctic Pacific from the 1950s to the 1980s, with the largest increases in biomass occurring along the northern boundary of the Gulf of Alaska. This would result in increased food availability for juvenile salmonids in the nearshore region and would lead to improved early ocean survival. Brodeur and Ware (1995) propose that the doubling of the zooplankton biomass in the area increased the carrying capacity for pelagic nekton by a factor of two.

5.3 Gulf of Alaska and the Bering Sea

The Gulf of Alaska and the Bering Sea have both exhibited changes in their environment and biota in recent decades (Livingston et al. 1999). Brodeur et al. (1999) surveyed catches of large medusae from the eastern Bering Sea from 1979 to 1997 and found a tenfold increase in medusae biomass that was gradual from 1979-1989 and increased dramatically after 1990. It is unknown whether this increase was due to human intervention or if it was due to environmental changes. However, the authors point out that there were concomitant changes in atmospheric and oceanographic variables in 1990, and that these changes are strong indications of a regime shift. Even though the biomass of medusae increased dramatically, no negative effects on recruitment of any fish species have been detected. However, walleye pollock (*Theragra chalcogramma*) has had only one strong year class since 1989 and summer zooplankton biomass on the south-east Bering Sea shelf has declined slightly in the 1990s (Brodeur et al. 1999).

Some confusion appears to exist regarding the status of walleye pollock stocks. Bulatov (1995) reports substantial declines in the catches of pollock in the western and central Bering Sea since 1989, but points out that Russian and United States scientists have different views of the state of the stock. Bulatov notes that the Russians say the abundance is declining in the eastern Bering Sea while Americans say the abundance is increasing. Merrick et al. (1997) point out that pollock abundance decreased through most of the central and western Aleutian Islands in the 1980s and 1990s, and declined through 1993 in the Gulf of Alaska. Nevertheless, according to Wepestad et al. (2000), walleye pollock is still the single most abundant fish species in the eastern Bering Sea and is of great commercial importance. Due to its large biomass, variations in the abundance of pollock are felt throughout the food web (Livingston, 1991).

The distribution of Bering Sea fish is affected by variations in ice cover. As mentioned previously, the extent of ice cover in the Bering Sea was reduced beginning in 1976 (Niebauer, 1988). Northward blowing winds associated with an intense Aleutian Low pushed the ice northward and resulted in reduced ice cover in warm years (Wyllie-Echeverria, 1995). Wyllie-Echeverria (1995) notes that pollock were not reported north of Bering Strait before 1976. Since then pollock have been present north of the Strait in years of light ice cover. Additionally, larval pollock were found in the Chukchi Sea, north of Bering Strait in 1988, which suggests a change in the spawning distribution, at least for a portion of the population. It is interesting to note that, as mentioned previously, Pacific hake are also spawning north of their traditional spawning grounds (McFarlane et al., 2000b). In addition to the presence of winter sea ice, the other dominant physical feature in the Bering Sea is the presence of a cold (< 2°C) mass of subsurface (between 50m and 100m) water in the summer that extends across the middle shelf domain from Russia to Alaska (Wyllie-Echeverria and Wooster, 1998). This cold pool of water is most developed in summers following an extensive winter ice cover.

Wyllie-Echeverria and Wooster (1998) proposed that the distribution of fish stocks that are sensitive to temperatures around 2°C should reflect ocean conditions. They found that Arctic cod (*Boreogadus saida*) are present only within the cold pool while the distribution of pollock, a subarctic species, is more variable. Pollock were rarely found in the cold pool of water but were more abundant on the outer continental shelf in cold years and dispersed across the entire shelf in warm years. Therefore, during the warmer regimes, the distribution of pollock expands while the distribution of Arctic cod contracts.

Wyllie-Echeverria and Wooster (1998) also noted that changes in fish distribution involve changes in predator-prey relationships, given that shifts in prey distributions can affect predators that are limited in their foraging range. The presence of cold water at depth could restrict the distribution of young pollock to the surface layer and to the warmer waters of the outer shelf where they could be more easily taken by predators (Decker et al., 1995). Francis et al (1998) note that the proportion of age-1 pollock in the diets of seabirds declined between the 1970s and the 1980s near the Pribilof Islands, and that they were less common in bottom trawl surveys at the same time. This was most likely due to a change in their distribution.

Quinn and Niebauer (1995) found consistent relationships between pollock recruitment at age 2 and environmental variables on a one year lag, and suggested that age 2 pollock recruitment is related to above normal air and sea temperatures and reduced sea ice extent 6-18 months earlier. They also found that environmental effects are "felt" more strongly at the juvenile stage than at the larval or egg stage. Another factor that affects recruitment is density dependent (biological) regulation (Livingston, 1993).

The roles of environment and density dependence need not be considered separately. For example, Wepestad et al. (2000) proposed that water mass transport due to wind forcing was the important regulating factor in pollock recruitment because transport is the mechanism that separates juvenile and adult pollock. They showed that strong year classes occur in warm years when juvenile pollock are transported inshore and away from the highly cannibalistic adults. In cold years, transport is reduced and the distributions of juvenile and adult pollock overlap, which can result in weak year classes due to cannibalism.

Margalef (1963) hypothesized that a sudden, prolonged external disturbance could reset or reorganize community structure and succession. Building on this, Bailey (2000) proposed that a regime shift could trigger community restructuring. He further suggested that immature (less structured) ecosystems could be more vulnerable to environmental influence acting on plankton, and that biological control might emerge as a dominant effect in more mature systems. Beamish (1993) found a majority of commercially important salmon and nonsalmon species ranging from California to the Bering Sea had exceptionally strong year classes between 1976 and 1978, immediately after the shift from cool to warm ocean conditions. This appears to support Bailey's hypothesis.

Bailey (2000) examined the impacts of changes in the Gulf of Alaska community on pollock recruitment. He found that recruitment was related to larval mortality immediately following the 1977 regime shift. However, 5-10 years after the shift, as the abundance of large predators built up, predation by flatfishes and cod on juvenile pollock had an increasing effect on recruitment. Bailey showed that the dependence of recruitment on environmental conditions that lead to high larval survival appears to have decreased in recent years, but not completely as a few relatively strong year classes appeared in the population in the 1990s. According to Bailey, these strong year classes may be attributed to reduced overlap of larvae and predators as a result of environmental conditions.

The Gulf of Alaska nekton community structure changed after the 1977 regime shift from one that was dominated by forage species such as shrimp and capelin to one dominated by piscivorous gadids and flatfish (Anderson et al., 1997; Anderson and Piatt, 1999; Mueter and Norcross, 2000). Mueter and Norcross (2000) point out that the observed decline in shrimp can be attributed more to increased predation by the large piscivorous fish rather than to fishing, because the decline followed, rather than preceded, the increase in large piscivores. It is also possible that the shrimp population may have been initially depressed by fishing and therefore more vulnerable to predation by the increasing population of piscivores (Orensanz et al., 1998). Anderson and Piatt (1999) point out that most of the declining species were pelagic while the species on the rise tended to be benthic or demersal (cod and flatfish).

Decker et al. (1995) note that the diet composition of seabirds reflects the distribution, abundance and availability of their prey. They examined the diets of black-legged kittiwakes (*Rissa tridactyla*), red-legged kittiwakes (*R. brevirostris*) and thick-billed murres (*Uria lomvia*) from the Pribilof Islands in the southeastern Bering Sea, and found that the diet composition changed after 1978. There was an overall decline in the presence of capelin (*Mallotus villosus*) and an increase of sandlance (*Ammodytes hexapterus*) in the diets in certain areas for some species after 1978. The use of gadids showed no consistent change though the period.

Decker et al. (1995) suggest that the reduction of capelin in the diets could be attributable to an altered distribution in response to warmer temperatures, as capelin are commonly associated with cold, ice-covered waters. They may have either moved deeper in the water column where they were unavailable to surface foraging sea birds, or they may have retreated to colder northern waters. In either case, the abundance of capelin decreased in the area around the Pribilof Islands in the late 1970s.

Livingston (1993) assessed the relative importance of pollock and herring in the diets of marine mammals, birds and groundfish in the eastern Bering Sea in 1985-1988. Cannibalism by pollock was determined to be the most important source of predation on age-0 pollock, while consumption of age-1 (10-19cm) fish was spread evenly between fish, pinnipeds and birds. The fishery took most pollock > 40cm. In terms of removals from the total biomass of pollock, groundfish (primarily cannibalism by pollock) were the most important source, followed by the fishery and then by marine mammals. Northern fur seals were the most important marine mammal predator, while common and thick-billed murres were the main sea bird predators.

Livingston (1993) compared her results with those of Kajimura and Fowler (1984), who examined the diets of marine mammals prior to 1980. She found that pollock biomass consumption by marine mammals in the 1980s was about half of the pre-1980 estimate. The higher consumption prior to the 1980s was a function of a larger pinniped population and a higher proportion of pollock in their diet (Livingston 1983). These results are contrary to diet studies that found Steller sea lions ate more pollock in the 1980s than in the 1970s (Alverson, 1992; Merrick et al., 1997).

Livingston (1993) found that Pacific cod was the most consistent groundfish predator of herring, and that groundfish predation was more a function of school encounter rates than of absolute abundance. Marine mammal and bird predation on herring was as important as groundfish predation, while the primary source of herring biomass removals was the fishery. The majority of herring biomass removed by the fishery, pinnipeds and fish was composed of fish greater than 20cm (age 3+ biomass), although groundfish tended to consume herring less than 20cm.

6. Marine Mammals and Sea Birds

Francis et al. (1998) acknowledge that the responses of top predators to climate change are difficult to interpret due to the confounding effects of natural responses and human influences (e.g., the 1989 Exxon Valdez oil spill, commercial pinniped harvest). In addition, climatic impacts may indirectly or directly affect birds and mammals, which will affect the time scale of response. For example, York (1995) correlated northern fur seal (*Callorhinus ursinus*) survival with environmental indices on time lags ranging from months to years before the birth of a cohort. Shorter time lags were used to relate direct effects of temperature on growth while longer lags were used to account for possible changes in production that would affect the food supply of a growing cohort.

Piatt and Anderson (1995) found significant declines in the piscivorous marine bird population in the Bering Sea between the 1970s and the 1990s concurrent with a shift in diet, from one dominated by capelin to one where capelin was essentially absent. Decker et al. (1995) found the diets of marine birds nesting on the Pribilof Islands changed beginning in 1978 (as previously noted). They also found reproductive performance declined.

Declines in the Bering Sea and Gulf of Alaska populations of Steller sea lions, fur and harbor seals have been observed since the mid-1970s (Springer, 1992; Francis et al., 1998; Trites, 1992; Trites and Larkin, 1996; Rosen and Trites, 2000). At the same time, the portion of the Steller sea lion population breeding between southeast Alaska and Oregon has been increasing (Calkins et al., 1999). The magnitude of the sea lion decline is equivalent to a 30-60% reduction in juvenile survival or to a 70-100% decline in female fecundity (Pascual and Adkinson, 1994). Different responses of separate segments of a pinniped population have been shown to be related to the extent of influence of environmental variations. For example, DeLong and Antonelis (1991 – in York, 1995) found that northern fur seals off California were adversely affected by the 1982-1983 El Nino, due to an increase in the foraging time of females and a decrease in pup survival, while no effect was detected in the eastern Bering Sea. This is consistent with previous findings that the 1982-83 El Nino had limited effect in the Bering Sea (Niebauer, 1988).

Several hypotheses have been offered to explain the decline of the Steller sea lion in the northeast Pacific such as: temporary population decline, delayed consequences of the pup harvest before 1972, short term variability in environmental conditions, and deterministic changes in the environment (Pascual and Adkinson, 1994). The latter might result from either long-term global environmental changes or from human intervention. Pascual and Adkinson (1994) tested the likelihood of each of these hypotheses and concluded that either long-term change in the environment or a stochastic catastrophe is responsible for the sea lion decline.

Merrick et al. (1997) found a strong correlation between diet diversity and sea lion population size in the Gulf of Alaska, and concluded that the population size declined in parallel with a decline in diet diversity. Merrick et al. examined sea lion diets from six areas in the Aleutian Islands and the Gulf of Alaska between 1990-1993 and found that in every area, the diet was dominated by either walleye pollock or Atka mackerel (*Pleurogrammus monopterygius*). The diet composition of Steller sea lions was different prior to the declining trends that began in the early 1970s in the eastern Aleutian Islands and the early 1980s in the Gulf of Alaska (Merrick et al., 1987). In the mid-1970s capelin were found in well over half the stomachs examined from sea lions near Kodiak Island in the Gulf of Alaska. Since then, capelin have rarely been found (Merrick et al. 1997). In 1985-1986 the diet of sea lions in the Gulf of Alaska became more concentrated on walleye pollock (Merrick and Calkins, 1996), and in 1990-1993 the diet became even more focused (Merrick et al., 1997). In addition, Merrick and Calkins (1996) found a decrease in the abundance of alternate prey (sandlance and capelin) that was concurrent with the decreasing diversity in the diet of sea lions.

Merrick et al. (1997) point out that it is problematic that no sea lion population has shown an increasing trend when the diet consists mainly of walleye pollock or Atka mackerel. It appears that at a minimum, two commonly available prey items are required. They suggest that a diverse diet is advantageous because of foraging efficiency, as diverse prey are easier to find, capture and handle. Merrick et al. (1997) point to work done by Fadely et al. (1994) to disregard the possibility that the need for multiple prey is due to differential energetic density (calories per gram) of the prey.

Fadley et al. (1994) found that captive California sea lions (*Zalophus californianus*) could maintain mass equally well on diets that consist entirely of herring or pollock. However, Rosen and Trites (2000) found evidence to the contrary for young Steller sea lions by testing the 'junk-food hypothesis' that states that Steller sea lion populations are declining because they are eating more pollock. Pollock contain fewer calories than fattier fishes like herring (Alverson, 1992). Rosen and Trites found that sea lions on a pollock only diet showed metabolic depression and lost weight. They further concluded that Steller sea lions would have to eat 35-80% more pollock than herring to maintain similar energy intakes, which is consistent with the junk food hypothesis. It should be noted that Rosen and Trites did not observe an increase in food intake in response to the lower calorie diet. It appears that once physically satiated, the sea lions will not continue to feed.

The change in sea lion diets reflects a combination of changes in diversity and abundance of prey species and an apparent preference of sea lions for small (< 30cm) schooling fish (Merrick et al., 1997). In the Gulf of Alaska, the Atka mackerel population has remained low since the 1980s while pollock populations also declined but were still more abundant than Atka mackerel. However, the pollock that were present in the Gulf of Alaska in 1990-1993 were the larger, older fish. Sea lions in the eastern Aleutian Islands were the only ones examined by Merrick et al. that had a significant amount of herring and sandlance in the diets. Although there is little supporting evidence, this suggests these species were more available here than elsewhere in the Gulf of Alaska and Aleutian Islands.

7. Summary

Environmental variability occurs across many spatial and temporal scales (Francis et al., 1998). The research we reviewed focused on decadal or longer-term variability in both physical and biological time series, although some (e.g., York, 1995) has concentrated on interannual variability. The intent of our review was to identify the timing of the regime shifts that occurred in the 20th century, and to characterize the nature of the biological responses from primary producers through to the top predators in the food chain.

We presented evidence that large-scale changes in atmosphere-ocean climate conditions should not be considered as random variations. Instead, they should be thought of as long term, stable conditions that can sometimes abruptly change state, as occurred over the north Pacific in 1925, 1947, 1977 and 1989 (Beamish et al., 1999; Mantua et al., 1997; Minobe, 1997; Overland, 1999). Changes in atmospheric pressure result in altered wind patterns that affect oceanic circulation and physical properties such as salinity and depth of the halo- and thermoclines. Phytoplankton productivity is directly affected by these physical oceanographic conditions, as shown by the near doubling of the chlorophyll *a* biomass around the time of the 1977 regime shift (Venrick et al., 1987; Venrick, 1994). This doubling was due to a deepening of the mixed layer that resulted from the intensification of the Aleutian Low in 1977 (Polovina et al., 1995). Such direct effects are manifest more quickly than indirect responses.

Regime shifts, such as those that occurred in the north Pacific, can have opposite effects on species living in different domains, or can affect different species living within a single domain in opposite ways. For example, the zooplankton biomass in the central north Pacific more than doubled between the 1950s and the 1980s (Brodeur and Ware, 1992), while off the coast of California the biomass of zooplankton declined by more than 80% (Roemmich and McGowan, 1995). Another example is how the trajectories of salmon populations in the California Current and Gulf of Alaska regions have gone in opposite directions (Francis et al., 1998). Even within the same production domain, groups of species, such as hake and herring in the SOG and off the WCVI, can respond differently (McFarlane et al., 2000a). The opposite response of populations in different regions is also observed for the top predators in the system. For example, Steller sea lion populations have been declining since the mid-1970s in the Bering Sea and Gulf of Alaska (Springer, 1992; Francis et al., 1998; Trites and Larkin, 1996), while populations off south-eastern Alaska to Oregon have been increasing (Calkins et al., 1999).

The effects of climatic forcing on fish are not necessarily easy to predict. Climate may indirectly affect fish populations through changes in predator distribution and abundance. Examples of indirect effects on fishes include the previously mentioned hake-herring interaction and the overlap of adult and juvenile walleye pollock distributions (Bailey, 2000). Climate is also more likely to affect sea birds and mammals in the North Pacific and Bering Sea through indirect means. There are indications that the Steller sea lion decline since the mid-1970s in the Gulf of Alaska and the Aleutian Islands is the result of a change in the relative abundance of different types of prey that are available to Steller sea lions. This change, from a diet dominated by herring and other fatty fishes to one dominated by gadids, may have adversely affected the health of Steller sea lions (Rosen and Trites, 2000).

Fisheries stock assessment has traditionally focused on controlling and limiting the effects of fishing in order to maintain fish populations at fixed viable levels. In addition, the yields from such populations are considered to be indefinitely sustainable. The key inputs required by traditional stock assessment models are the stock-recruitment relationship and the virgin unfished biomass, both of which are assumed to be constant. However, there is a considerable body of scientific literature indicating that the productivity of fish stocks varies naturally in association with climate, and that the effects of fishing are superimposed on this natural regulation. This indicates that a new approach to managing fisheries, one that incorporates climatic as well as fisheries effects, is required.

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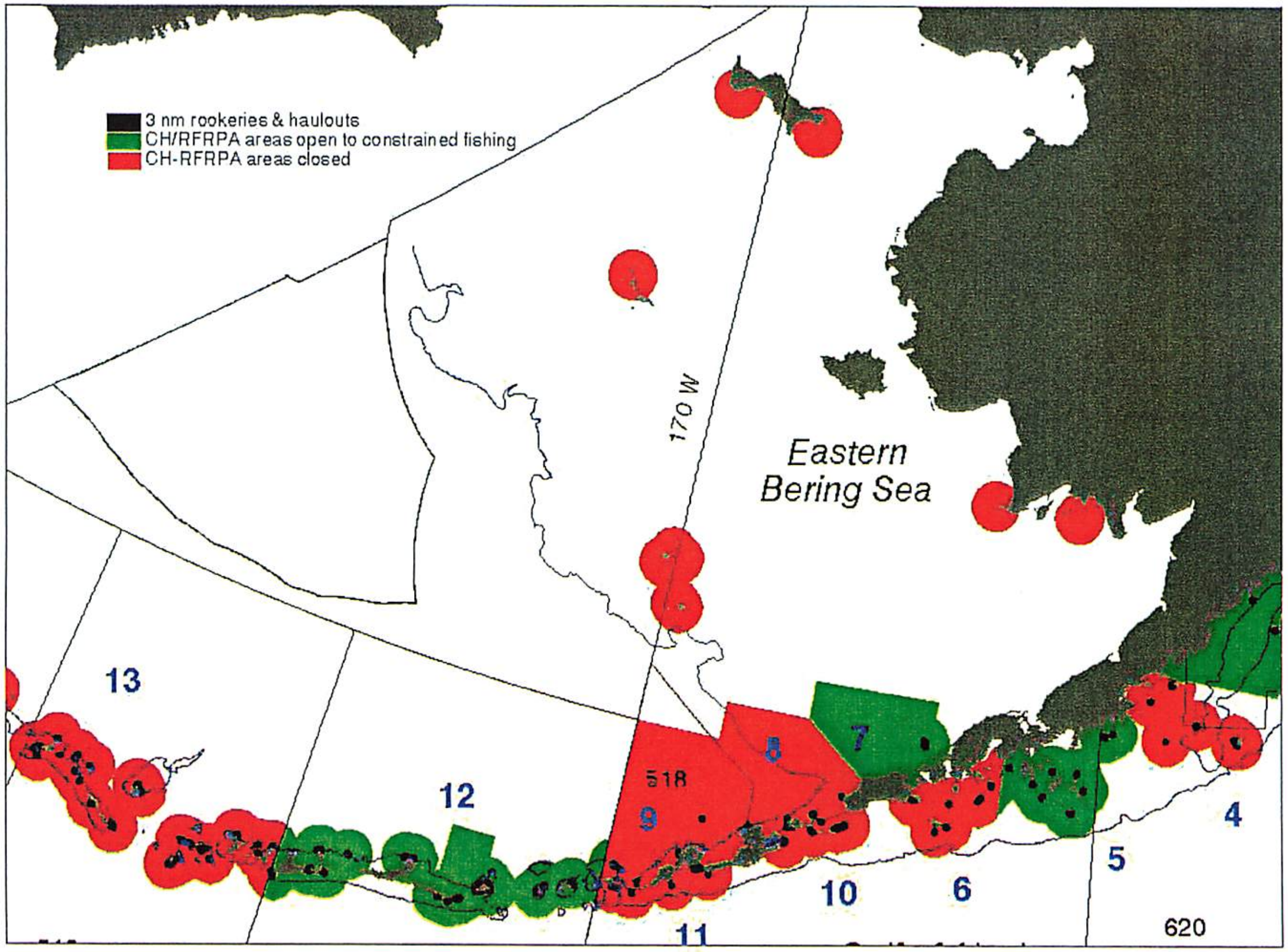


Figure 9.1a. CH-RFRPA areas closed and open to constrained fishing for pollock, Pacific cod, and Atka mackerel fisheries in the eastern Bering Sea. Areas 7-9 are in the eastern Bering Sea groundfish fishery management region.

NMFS ?

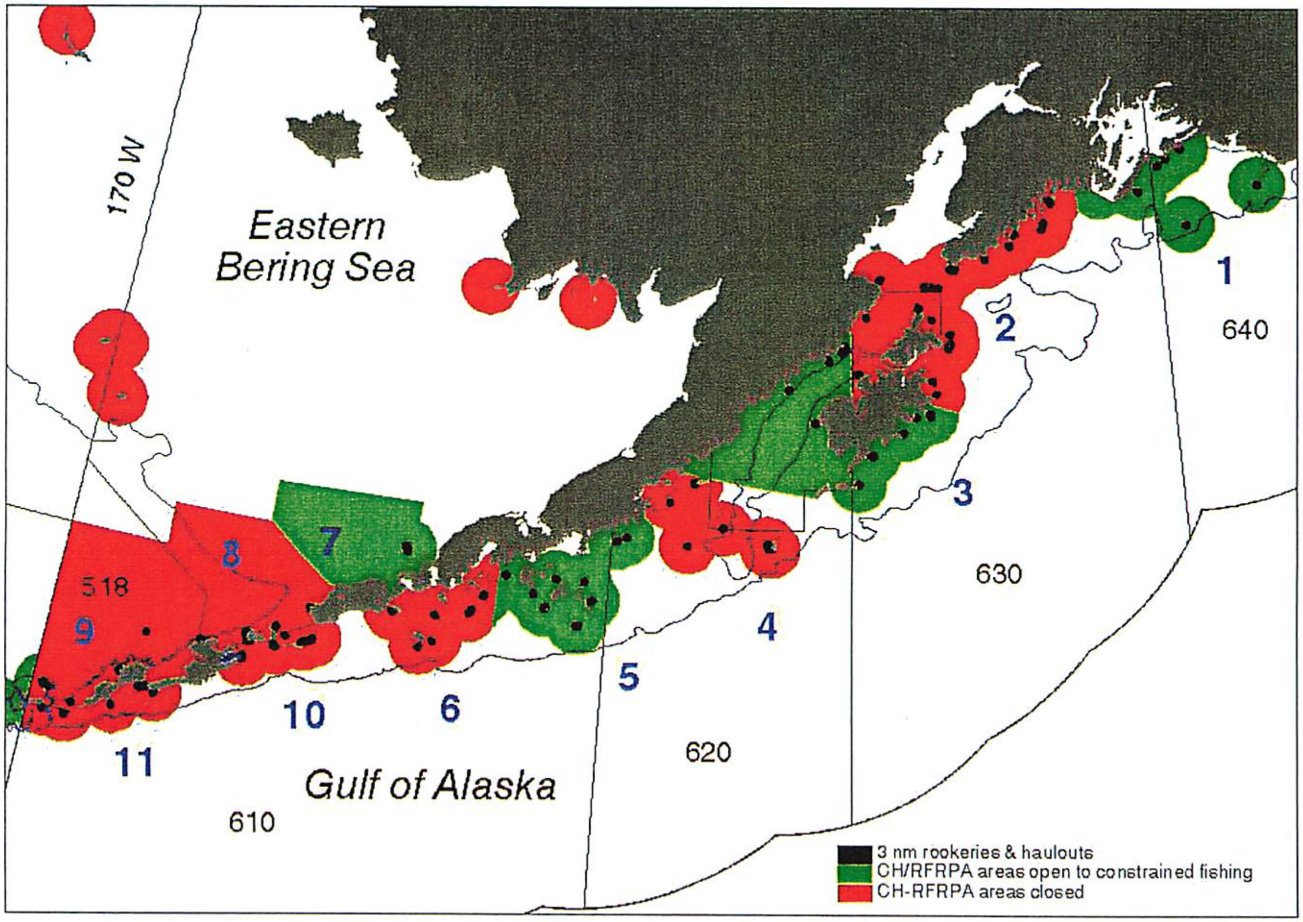


Figure 9.1a. CH-RFRPA areas closed and open to constrained fishing for pollock and Pacific cod fisheries in the Gulf of Alaska. Areas 1-6, 10 and 11 are in the Gulf of Alaska groundfish fishery management region (areas 610-640).

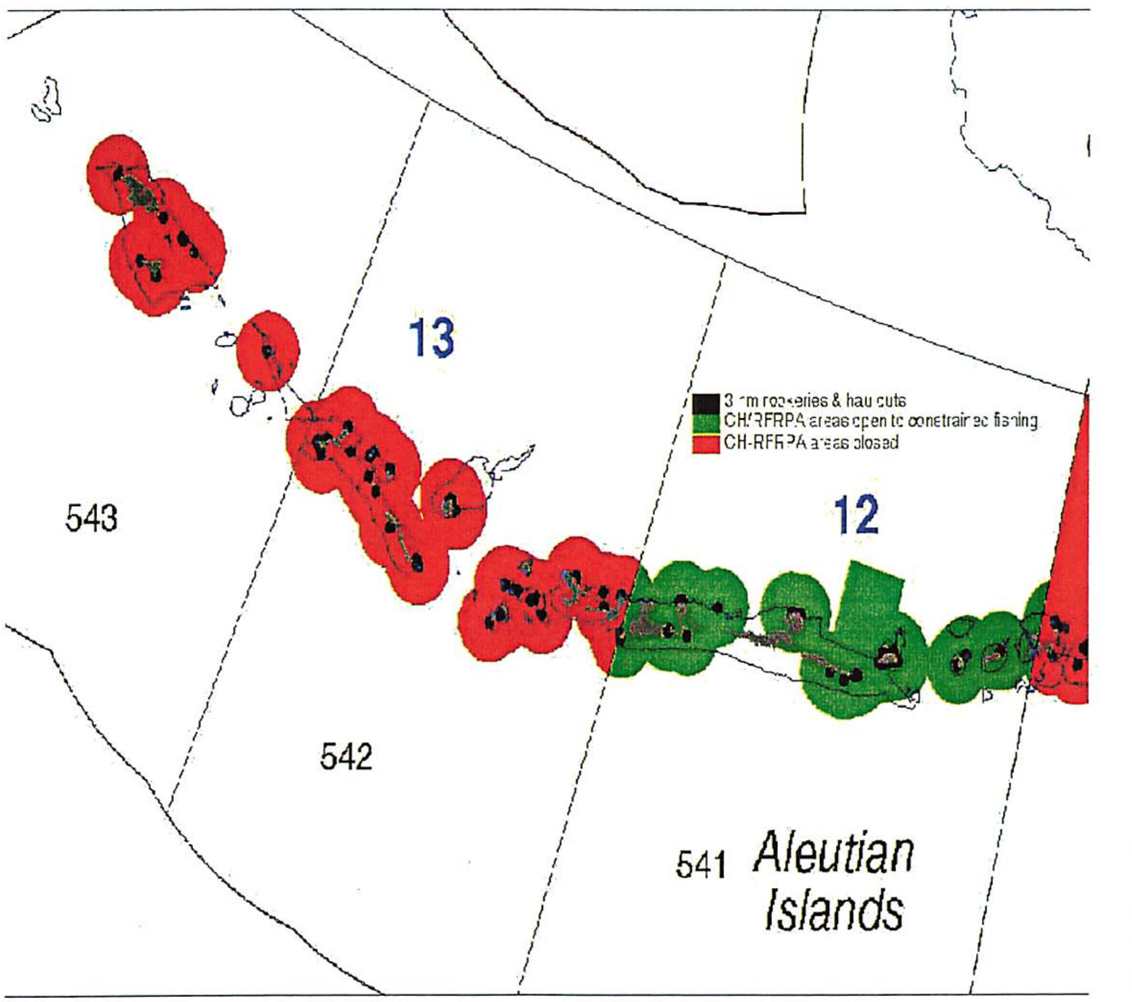


Figure 9.1c. CH-RFRPA areas closed and open to constrained fishing for pollock, Pacific cod, and Atka mackerel fisheries in the Aleutian Islands. Areas 12 and 13 are in the Aleutian Islands groundfish fishery management region (areas 541-543).

North Pacific Fishery Management Council
December 9, 2000 - 8:15 am

Captain O'Shea - Thank you Mr. Chairman - I sat through public testimony yesterday and had not asked any questions of anybody, but felt upon reflection last night, that it would be both helpful and proper for me to express to the Council, the concerns that the Coast Guard has with the RPAs as proposed, and to allow you to at least hear our side of these concerns. They include both from a safety perspective and enforcement perspective.

I would like to just take a minute if I could to run through some of those issues. Clearly the RPAs represent a clear strategy to push the fleet further offshore - that's inherent in the problem that has been defined here. But, for fishing vessels that's going to be compounded with increased economic pressures, for these folks to take chances that they ordinarily might not have to take... and those pressures that I heard yesterday include increased running times to go offshore; we heard about increased fuel prices; built into the RPAs is reduced TACs. We also heard concern in the Gulf of Alaska for people that are going to be worried about maintaining or establishing their catch history.

Now, the Coast Guard will respond to this like we have for some of the other derby type fisheries and this is what this is going to set up in our mind, particularly in the winter months, by trying to do vessel safety checks before these boats leave. And we will try to also insure that we have our search and rescue resources positioned as best we can to respond. But realistically these are Band-Aids to the problem. What we really need is a realistic alternative for these folks, rather than forcing them into risking both their vessels and their crews. From an enforcement standpoint, we certainly heard a lot of testimony yesterday in just reviewing the BiOp and RPAs, that creates a multi patchwork quilt of regulations, openings, and closures, and I think that public testimony yesterday, about stressing the importance and going forward with this, of getting these regulations published in a clear way, that could be understood by both the industry, so they could comply with it and with the enforcers, so that we can have half a chance of monitoring compliances, is a critical issue here.

Frankly, the no trawling ban to me seems to be a fairly straight forward order compared to the RPAs, yet I don't have to remind anybody, shortly after the no trawling ban went into effect, twenty eight of the industry guys came forward and said you know what? We couldn't figure it out and we're self reporting ourselves as being in violation. What I see in the RPAs is going to be a heck of lot more complex than that. I can't patrol all of those areas and be in there every single day. To me it seems it's really going to be critical, that as we go down this path, if that's what is decided, that it be with an idea of working with industry, so we have those folks in agreement of at least trying to comply with this thing, rather than expecting the Coast Guard and NMFS Enforcement to review everybody's logs and see if we can catch them making a mistake.

The other enforcement concerns that I have, Mr. Chairman, is that we have a major industrial pollock fishery occurring in the Bering Sea, and I told you on Wednesday, it's happening 5 miles away from our maritime boundary line. These guys don't have observers onboard, they don't have catch limits I don't think, and I don't want to be up here in February telling you that we have opened the EEZ to Russian fishing because we got all our Coast Guard cutters down patrolling the rookery areas. So my point there is we're spread very thin and I'm going to have 2 cutters up here in January. Two cutters, major cutters, to do rookery patrols, search and rescue, as well as the other things that we do. We have an opilio crab fishery that is going to go on the 15th of January and I don't have to tell folks what that means for us and the Coast Guard.

So I guess my bottom line, Mr. Chairman, is to re-enforce the concerns that were brought up in public testimony yesterday, to publicly state that the Coast Guard is concerned about the impacts of these RPAs from two perspectives, our resources are limited, and realistically say we only have 2 Coast Guard cutters up here, where are the rest? Well I can tell you a lot them are down off Central and South America, in our Eastern Pacific counter narcotics program. Those vessels are getting multi-ton cocaine busts, if not on a weekly basis, certainly on a monthly basis, I don't think it's realistic for us to expect that we are going to be successful in shifting national priorities away from that mission, to send more resources up to Alaska to respond to Steller sea lion problems. At least that's not the way Admiral Barrett and I are looking at this problem. We are saying that the resources we have available, on all the jobs up here, is fixed. We are going to try and do the best job that we can, but realistically we need to look at the other things that we have on our plate and what the priorities are. So to the extent that's helpful in your deliberations today and to the extent that these concerns are helpful to the agency as they go forward with looking at these RPAs, I certainly appreciate your patience and indulgence in letting me express them. Thank you, Mr. Chairman.

–Captain Vince O'Shea

NMFS?

EXAMPLE SEASON ALLOCATIONS AND OPEN CRITICAL HABITAT HARVEST LIMITATIONS DERIVED UNDER THE RPA AND PLAN TEAM RECOMMENDATIONS FOR 2001 ABCS

EBS Pollock

Harvest amounts are based on an assumed 2001 TAC of 1.3 million mt. The global control rule did not modify the maximum ABC because BSAI pollock is above the B_{40} threshold.

Season	**A**	**B**	**C**	**D**
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
Seasonal TAC	A + B (40 % annual TAC) **520,000 mt**		C + D (60 % annual TAC) **780,000 mt**	
Limit inside Area 7	max 7.3 % annual TAC **94,900 mt**	max 4.6 % annual TAC **59,800 mt**	max 0.9% annual TAC **11,700 mt**	max 1.4 % annual TAC **18,200 mt**

EBS Pacific cod

Based on the average proportions of the biomass in the Bering Sea and Aleutian Islands subareas, harvest amounts are based on the assumption that the Bering Sea represents 88 percent of the Plan Team's recommended BSAI ABC, or (.88)(188,000) = 165,440 mt. The Plan Team's recommended BSAI ABC (188,000 mt) is less than the maximum ABC derived from the Global control rule (204,618 mt), and is used accordingly.

Season	**A**	**B**	**C**	**D**
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
Seasonal TAC	A + B (40 % annual TAC) **66,176 mt**		C + D (60 % annual TAC) **99,264 mt**	
Limit inside Area 7	max 6.9 % annual TAC **11,415 mt**	max 1.3 % annual TAC **2,151 mt**	max 2.5 % annual TAC **4,136 mt**	max 6.0 % annual TAC **9,926 mt**

GOA Pollock

The 2001 GOA pollock ABC as recommended by the Plan Team is 105,810 mt. This ABC is greater than the maximum ABC derived from the global control rule (86,922 mt). This is the total of the pollock ABCs for the western-central GOA (81,882 mt) plus the East Yakutat-SE Outside (6,460 mt) minus the Prince William Sound GHL (1,420 mt). The federally managed pollock TAC in the western and central GOA is 80,462 mt; overall W-C apportionments are listed below, followed by area-specific apportionments.

GOA – Area 610 Assumes 28% of GOA ABC in area 610 during A/B; 41% of GOA ABC in area 610 during C/D

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
Seasonal TAC	A + B (40 % annual TAC) **9,122 mt**		C + D (60 % annual TAC) **19,808 mt**	
Limit inside CH-RFPRA	max 4.8 % annual TAC **3,863 mt**	max 4.8 % annual TAC **3,863 mt**	max 2.1 % annual TAC **1,711 mt**	max 2.1 % annual TAC **1,711 mt**

GOA – Area 620 Assumes 60% of GOA ABC in area 620 during A/B; 24% of GOA ABC in area 620 during C/D.

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
Seasonal TAC	A + B (40 % annual TAC) **19,628 mt**		C + D (60 % annual TAC) **11,766 mt**	
Limit inside CH-RFPRA	max 10.7% annual TAC. **8,591 mt**	max 10.7% annual TAC **8,591 mt**	max 4.6 % annual TAC **3,665 mt**	max 4.6% annual TAC **3,665 mt**

GOA – Area 630 Assumes 8% of GOA ABC in area 630 during A/B; 32% of GOA ABC in area 630 during C/D.

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
Seasonal TAC	A + B (40 % annual TAC) **2,640mt**		C + D (60 % annual TAC) **15,512mt**	
Limit inside CH-RFPRA	max 0.1 % annual TAC **86 mt**	max 0.1 % annual TAC **86 mt**	max 2.2% annual TAC **1,800 mt**	max 2.2 % annual TAC **1,800 mt**

GOA – Area 640 Assumes 2.5% of GOA ABC in area 640

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
Seasonal TAC	A + B (40 % annual TAC) **794 mt**		C + D (60 % annual TAC) **1,192 mt**	
Limit inside CH-RFPRA	max 0.2 % annual TAC **158 mt**	max 0.2 % annual TAC **158 mt**	max 0.3 % annual TAC **237 mt**	max 0.3 % annual TAC **237 mt**

GOA Pacific cod

GOA – Area 610 Amounts based on assumed GOA 2001 TAC of 24,000 mt, which is equal to the Area 610 ABC recommended by the GOA Plan Team.

Season	**A**	**B**	**C**	**D**
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
Seasonal TAC	A + B (40 % annual TAC) **9,600 mt**		C + D (60 % annual TAC) **14,400 mt**	
Limit inside CH-RFPRA	max 1.7 % annual TAC **1,153 mt**	max 0.1 % annual TAC **68 mt**	max 0.1% annual TAC **68 mt**	max 0.1 % annual TAC **68 mt**

GOA – Area 620/630 Amounts based on assumed GOA 2001 TAC of 38,650 mt, which is equal to the Area 620/630 ABC recommended by the GOA Plan Team.

Season	**A**	**B**	**C**	**D**
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
Seasonal TAC	A + B (40 % annual TAC) **15,460 mt**		C + D (60 % annual TAC) **23,190 mt**	
Limit inside CH-RFPRA	max 8.0 % annual TAC **5,424 mt**	max 2.2 % annual TAC **1,492 mt**	max 3.7 % annual TAC **2,508 mt**	max 3.8 % annual TAC **2,576 mt**

GOA – Area 640 Amounts based on assumed GOA 2001 TAC of 4,750 mt, which is equal to the Area 640 ABC recommended by the GOA Plan Team.

Season	**A**	**B**	**C**	**D**
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
Seasonal TAC	A + B (40 % annual TAC) **1,900 mt**		C + D (60 % annual TAC) **2,850 mt**	
Limit inside CH-RFPRA	max 0.4 % annual TAC **271 mt**	max 0.2 % annual TAC **135 mt**	max 0.2 % annual TAC **135 mt**	max 0.3 % annual TAC **203 mt**

AI Pollock

In the AI, pollock ABC as recommended by the Plan Team for 2001, is 23,800 mt, which is equal to the maximum ABC derived from the global control rule and is used accordingly.

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
Seasonal TAC	A + B (40 % annual TAC) **9,520 mt**		C + D (60 % annual TAC) **14,280 mt**	
Limit inside CH-RFPRA	max 0.9 % annual TAC **214 mt**	max 1.0 % annual TAC **238 mt**	max 1.8 % annual TAC **428 mt**	max 1.7 % annual TAC **404 mt**

AI Pacific cod

Based on the average proportions of the biomass in the Bering Sea and Aleutian Islands subareas, harvest amounts are based on the assumption that the Aleutian Islands represents 12 percent of the Plan Team's recommended BSAI ABC, or (.12)*(188,000) = 22,560 mt. The Plan Team's recommended BSAI ABC (188,000 mt) is less than the maximum ABC derived from the global control rule (204,618 mt), and is used accordingly.

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
Seasonal TAC	A + B (40 % annual TAC) **9,024 mt**		C + D (60 % annual TAC) **13,536 mt**	
Limit inside CH-RFPRA	max 13.7 % annual TAC **3,090 mt**	max 7.4 % annual TAC **1,669 mt**	max 4.4 % annual TAC **993 mt**	max 9.7 % annual TAC **2,188 mt**

BSAI Atka mackerel

The BSAI Atka Mackerel ABC as recommended by the Plan Team for 2001 is 58,700 mt. This ABC is less than the ABC derived from the Global Control Rule (97,254 mt) and is used accordingly.

BSAI – Eastern Aleutians/Bering Sea (541/BS) Amounts based on assumed area 541 2001 TAC apportionment of 6,600 mt, which is the Area 541 ABC recommended by the BSAI Plan Team.

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **2,640 mt**		C + D (60 % annual TAC) **3,960 mt**	
Limit inside CH-RFPRA	max 1.7 % annual TAC **998 mt**	max 1.7 % annual TAC **998 mt**	max 2.5 % annual TAC **1,468 mt**	max 2.5 % annual TAC **1,468 mt**

BSAI – Central Aleutians (542) Amounts based on assumed AI district 542 2001 TAC apportionment of 28,500 mt, which is the Area 542 ABC recommended by the BSAI Plan Team. Fishing is prohibited within CH-RFRPA areas.

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **11,400 mt**		C + D (60 % annual TAC) **17,100 mt**	

BSAI – Western Aleutians (543) Amounts based on assumed area 543 2001 TAC apportionment of 23,600 mt, which is the Area 543 ABC recommended by the BSAI Plan Team. Fishing is prohibited within CH-RFRPA areas.

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **9,440 mt**		C + D (60 % annual TAC) **14,160 mt**	

Biological Opinion-Authorization of BSAI and GOA groundfish fisheries based on Fishery Management Plans

- Section 1- Purpose and Consultation History
- Section 2- Description of the Proposed Action
- Section 3- Description of the Action Area
- Section 4- Status of Species and Critical Habitat
- Section 5- Environmental Baseline
- Section 6- Effects of the Federal Action

FMP Biological Opinion

- Section 7- Cumulative Effects
- Section 8- Conclusions
- Section 9- Reasonable and Prudent Alternatives
- Section 10- Incidental Take Statement
- Section 11- Conservation Recommendations
- Section 12- Reinitiation Statement
- Section 13- Literature Cited

Jeopardy-

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species."

Adverse modification of CH-

“Destruction or adverse modification” means a direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species. Such alterations include, but are not limited to, alterations adversely modifying any of those physical or biological features that were the basis for determining the habitat to be critical.”

Section 1- Purpose and History

- Intent- fulfill NMFS' obligation under section 7 of the ESA
- 26 Jan 1996 BiOp on TAC specifications for BSAI and GOA groundfish
- 3 Dec 1998 BiOp on BSAI Atka mackerel, BSAI pollock, and GOA pollock fisheries (jeopardy!)
- 22 Dec 1998 BiOp on 1999 TAC specifications (Court ruled that the decision was "arbitrary and capricious for failing to include a comprehensive analysis of the groundfish fisheries and their cumulative effects)
- 23 Dec 1999 BiOp on 2000 TAC specifications

Section 2- Proposed Actions

- Describes the FMPs that guide the management of BSAI and GOA groundfish fisheries.
- Legal Mandate- MSA

Section 3- Action Area

- "all areas to be affected directly or indirectly by the Federal action"
- Entire Bering Sea and the GOA from the continental slope shoreward
- Eastern border of management area 541 (Islands of the Four Mountains) to the western border of area 543 (midway between Attu Island and Medney Island

Section 4- Status of Species and Critical Habitat

- 25 listed "species" in action area
- Critical habitat for 1 "species" (Steller sea lion)
- 7 "species" of large whales
- 2 "species" of pinnipeds
- 12 "species" of fish
- 1 "species" of marine turtle
- 3 "species" of marine birds

Section 5- Environmental Baseline

- Past and present impacts of all state, Federal or private actions and other human activities in the action area
- Impact of natural climatic variability (regime shift) on the marine ecosystem
- Impacts of killer whale predation on listed species
- Human population growth in action area
- Subsistence harvests of listed species
- Impact of State and Federal commercial fishing (1800s – 1950s, 1950s – 1970s, and 1970s to the present)
- Impacts of oil and gas development
- Impacts of research and other activities
- Summary of conservation measures for listed species

Section 6- Effects of the Federal Action

- Description of FMP process for setting catch limits
- Groundfish depletions in the action area
- Localized depletion at the regional scale
- Niche overlap between fisheries and listed species
- Steller sea lion case study
- Indirect effects of the FMP on listed species and their environment
- Response of listed species to Federal action

Section 6- Effects of the Action Frequency of occurrence of Steller sea lion prey from scats > 10% (1990-1998)

Food Items	*GOA*	*EBS/AI*
Pollock	73%	54%
Pacific cod	34%	21%
Atka mackerel	5%	78%
Arrowtooth fl.	22%	4%
Cephalopods	5%	16%
Herring	11%	8%
Salmon	43%	20%
Sandlance	14%	3%

Section 6: Effects of the Action

Seven Questions on Competitive Interactions

- Do SSL forage on target species?
- Do SSL forage on target species at a rate of at least 10%?
- Does the size of SSL prey overlap with the size caught by Commercial fisheries?

4. Does the fishery overlap spatially with foraging SSL on this species?
5. Does the fishery operate at the same time SSL forage on this species?
6. Does the fishery operate at the same depth SSL forage on this species?
7. Does the fishery operate in a spatially or temporally compressed manner in SSL critical habitat?

Questions 1-6: Value of 1 pt for a yes answer

Question 7: Value of 2 pts for a yes answer.

Section 6: Effects of the Action Scores to Questions on Competitive Interactions (score of 2 and above)

Fished Species	*BS/AI*	*GOA*
Pollock	8	8
Pacific cod	8	8
Atka mackerel	8	8
Arrowtooth fl.	2	2
Squid	2	N/A
Forage fish	2	2

Section 7- Cumulative Effects

- Include the effects of future State, tribal or private actions in the action area
- Direct effects
- Indirect effects of Alaska State commercial fisheries, sport fisheries, and subsistence fisheries
- Alaska State oil and gas leasing

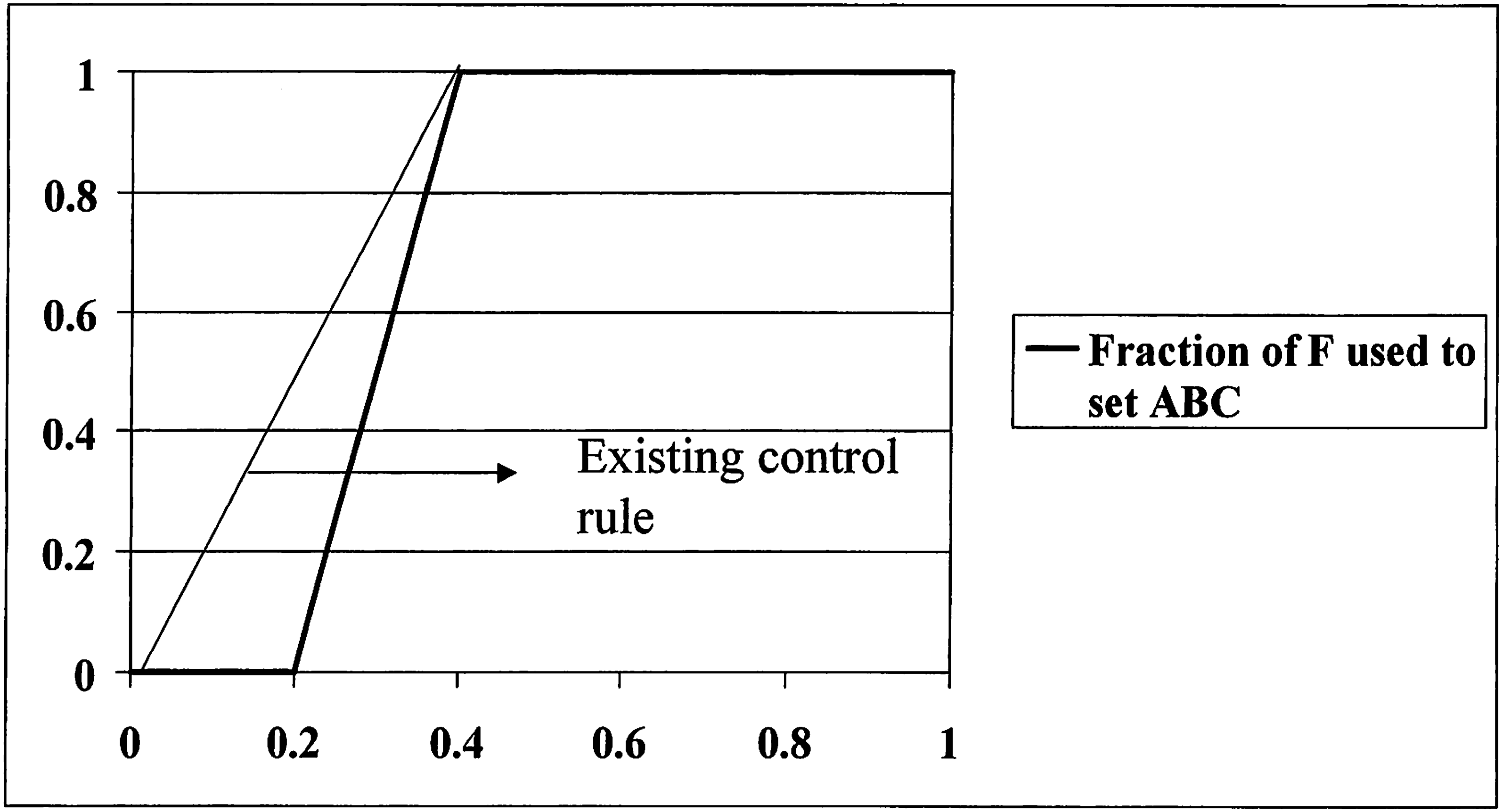
Section 8- Conclusion

- Conclude that FMP is not likely to jeopardize any of the listed species, except the western Steller sea lion
- Conclude that the FMP is likely to adversely modify the designated critical habitat of Steller sea lions

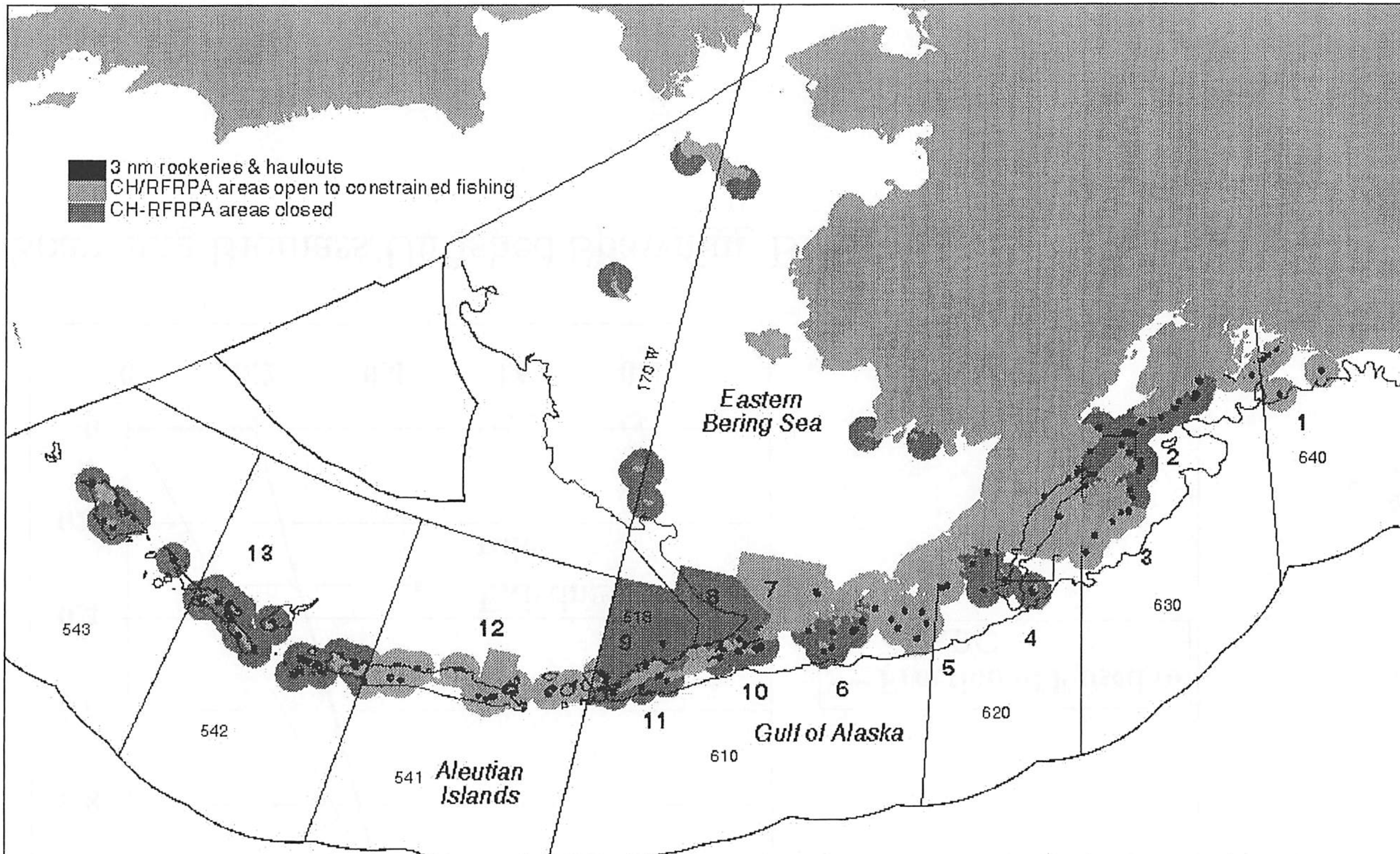
Section 9- Reasonable and Prudent Alternative

- Global Control Rule
- CH Closures to Eliminate Competition (66%)
- 3 nm no-entry zones around rookeries
- 3 nm no fishing by Fed. Permitted vessels around haulouts
- Seasonal harvest limits in CH (4 seasons)
- Seasonal harvest limits outside CH (2 seasons)
- Closure in CH and no trawling from 1 Nov through 20 January
- Spatial apportionment of TAC in open areas in CH
- Monitoring requirement (3 blocks, 13 areas)

Global Control Rule



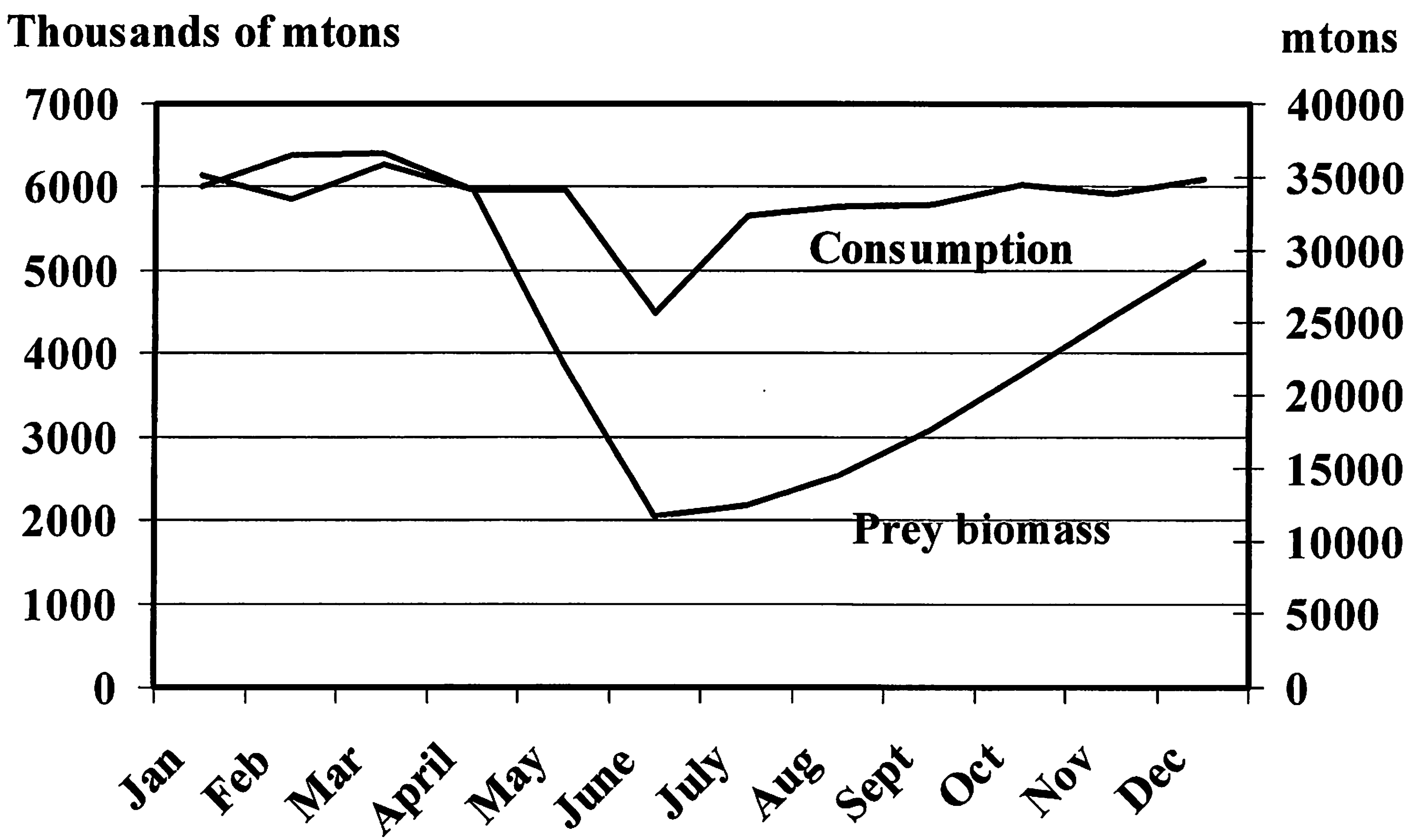
Spawning Biomass/Unfished Spawning Biomass



Draft-2 Steller Sea Lion RPA Adaptive Management Areas

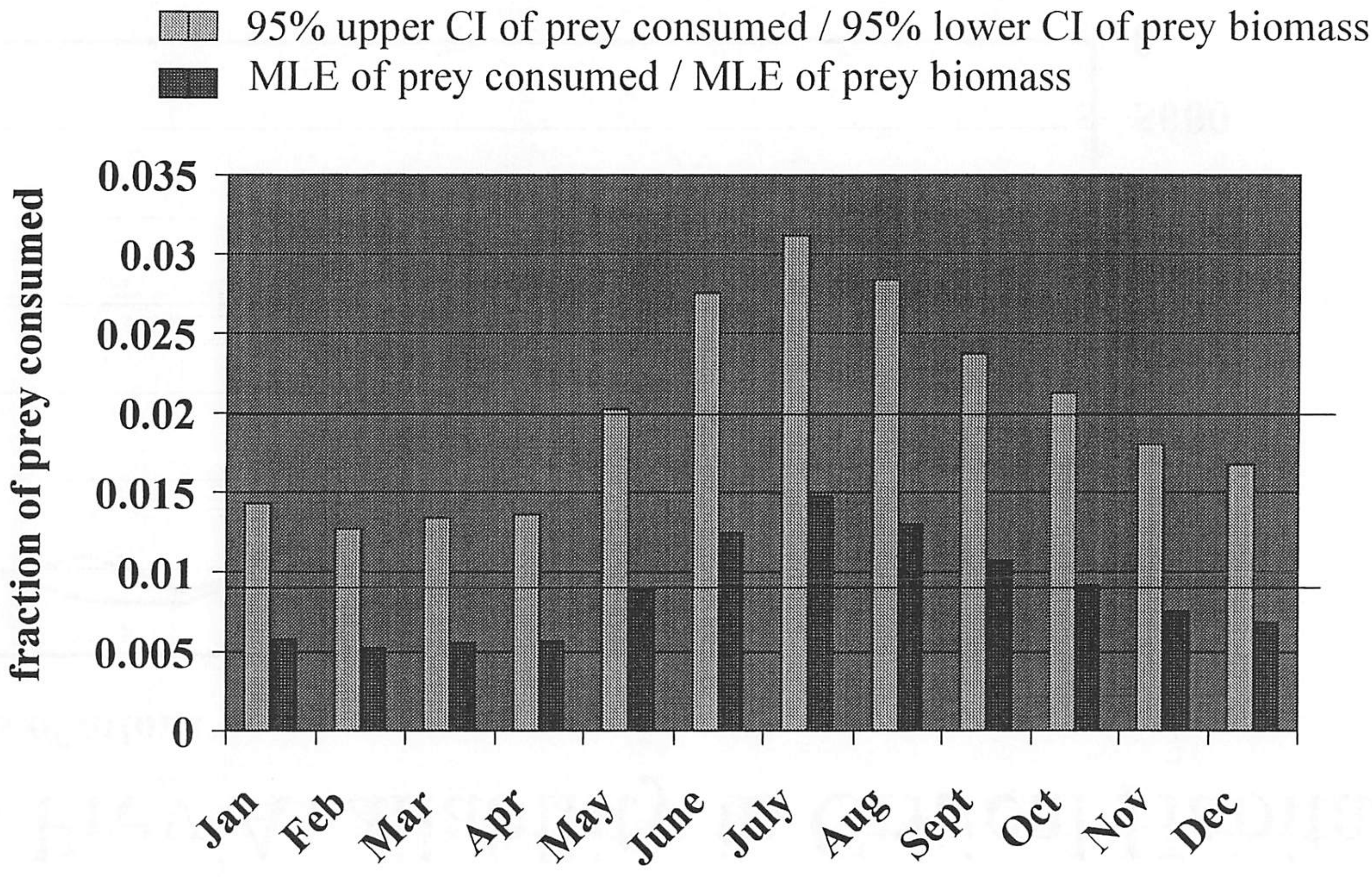
Open and closed areas refer to the pollock, Pacific cod, and Atka mackerel fisheries only. These fisheries will also be subject to seasonal spatial allocations in all three regions and daily harvest limits in the EBS east of 170W.

Steller Sea Lion Consumption versus Prey Availability in Critical Habitat



**Biomass estimates of prey are for pollock, Pacific cod and Atka mackerel*

Steller Sea Lion: Fraction of prey Consumed



**Biomass estimates of prey are for pollock, Pacific cod and Atka mackerel*

Implementation of the RPA Seasonal Allocation

	A	B	C	D
EBS, AI, or GOA	Combined Season- 20 10 June	A/B Jan- (40% of Tac)	Combined Season 11 Oct (60%	C/D June – 31 Of Tac)
CH-RFRPA	A season 20 Jan-31 March	B season 1 Apr – 10 June	C season 11 June-21 Aug	D season 22 Aug – 31 Oct

Experimental Design: Non-pup Steller count data by Area

Area	*1991*	*1992*	*1994*	*1996*	*1998*	*2000*	*Trend (r)*
1	4276	3956	3344	2302	1790	2134	-0.10
2	5002	4951	4812	3941	2977	2935	-0.07
3	1197	923	1165	822	943	779	-0.04
4	2385	2246	1744	1579	1647	1262	-0.06
5	2524	2417	2727	2523	2814	2033	-0.01
6	2474	2850	2702	2884	2669	2398	-0.01
7	910	1198	1160	1570	1390	1204	0.03
8	303	532	778	659	836	624	0.07
9	1127	1067	921	879	736	884	-0.04
10	1419	1363	1437	1361	1349	1105	-0.02
11	1757	1734	1686	1608	1654	1316	-0.03
12	6049	5254	4877	4620	4969	4925	-0.02
13	7599	7396	6000	5847	5439	3588	-0.07
total	**37022**	**35887**	**33353**	**30595**	**29213**	**25187**	**-0.04**

Experimental Design: Trends in Open and Closed Areas by Block

Block	Status	Trends (r)	Lower CI	Upper CI
I	open	-0.05	-0.07	-0.03
	closed	-0.05	-0.06	-0.04
II	open	-0.01	-0.03	0.01
	closed	0.0	-0.04	0.05
III	open	-0.02	-0.05	0.01
	closed	-0.07	-0.11	-0.04

Outcomes and Conclusions

Outcome	*Evidence*	*Conclusions*
1	O/C- better	Conservation measures adequate
2	O-better C- not better	Add restrictions in CH
3	O/C- not better	Fishery has no effect
4	O- better C- not better	Fishery promotes recovery

Section 10- Incidental Take Statement

- Take is defined to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in such conduct
- Determination that the anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat when RPA is implemented
- Reasonable and Prudent Measures

Section 10- Reasonable and Prudent Measures

NMFS concludes that the following reasonable and prudent measures Are necessary and appropriate to minimize the impacts from fisheries considered in this opinion to the listed Steller sea lion.

NMFS shall monitor the take of Steller sea lions incidental to the BSAI and GOA groundfish fisheries.

NMFS shall monitor groundfish landings on a daily basis.

NMFS shall monitor the location of all groundfish catch to determine whether the catch was taken inside critical habitat (zones 1-13) or outside of critical habitat in the BSAI or GOA.

NMFS shall monitor vessels fishing for groundfish inside specified closed areas for pollock, Pacific cod, and Atka mackerel (as required by the RPA) to determine if they are directing fishing for those species.

Section 11- Conservation Recommendations

- CR's are discretionary agency activities to minimize or avoid adverse effects of a proposed action, to help implement RP, or to develop implementation
- 10 CR's are discussed

Section 12- Reinitiation Statement

- Closing statement
- Reinitiation is required where the: 1) amount of incidental take is exceeded, 2) new information that may affect listed species or CH, 3) Federal action is modified in a manner that may affect listed species or CH, or 4) a new species is listed or CH designated that may be affected by the Federal action

ALLOCATION OF SEASON & CH HARVEST LIMITS IN GOA

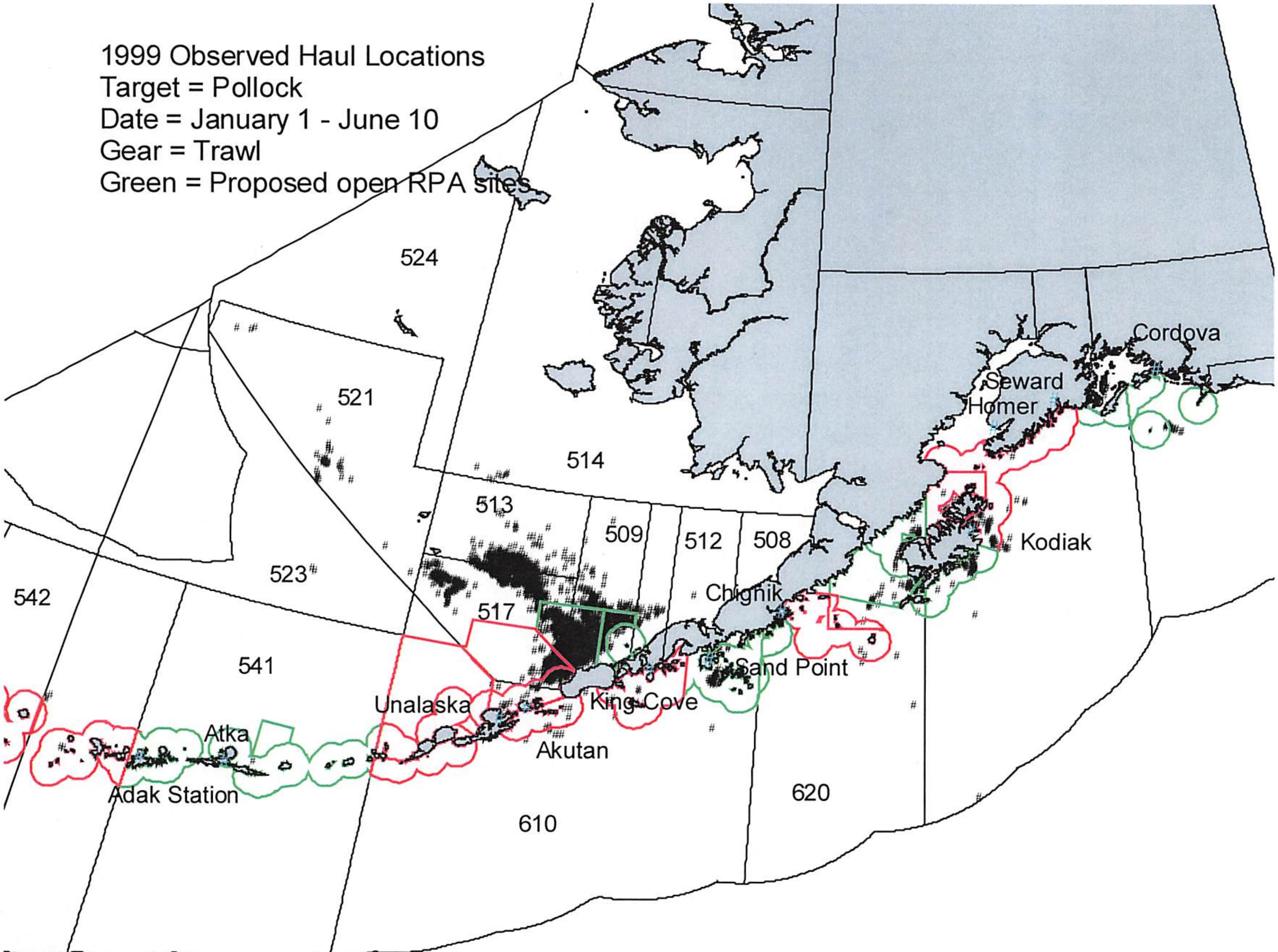
- GOA pollock and Pacific cod
  - Inshore/offshore (cod only)
- Non-exempt AFA vessels prohibited from fishing in CH for GOA pollock & Pacific cod
- Existing AFA sideboard exemptions
- Existing trip limits for pollock and tender vessel prohibitions

ALLOCATION OF SEASON & CH HARVEST LIMITS IN BSAI

- BSAI Pacific cod and Atka mackerel
  - Apportioned among gear groups & sectors proportional to existing regulatory percentages
  - CH harvest limits would be specified by gear and sector as well
- BSAI pollock
  - Apportioned among sectors proportional to AFA and existing implementing regulations
  - Includes 99 ft vessel special access provision in SCA
  - CH harvest limits by sector by season
  - BSAI/GOA cross over and exclusive fishing season provisions

MONITORING OF CH HARVEST LIMITS

- **Directed fishing harvest limits**
- **100% C/P observer coverage in CH**
- **Fish ticket/shoreside electronic logbook**
  - Manage harvest limits
  - Monitor DF closures in CH – vessels that fish in CH closed to pollock, cod, or Atka Mackerel would be required to comply with MRB percentages for those species for an entire trip, regardless of where they fish
  - Requires extending scope of shoreside E-log
- **Pursue VMS via Council process**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Date = January 1 - June 10
Gear = Trawl
Green = Proposed open RPA sites
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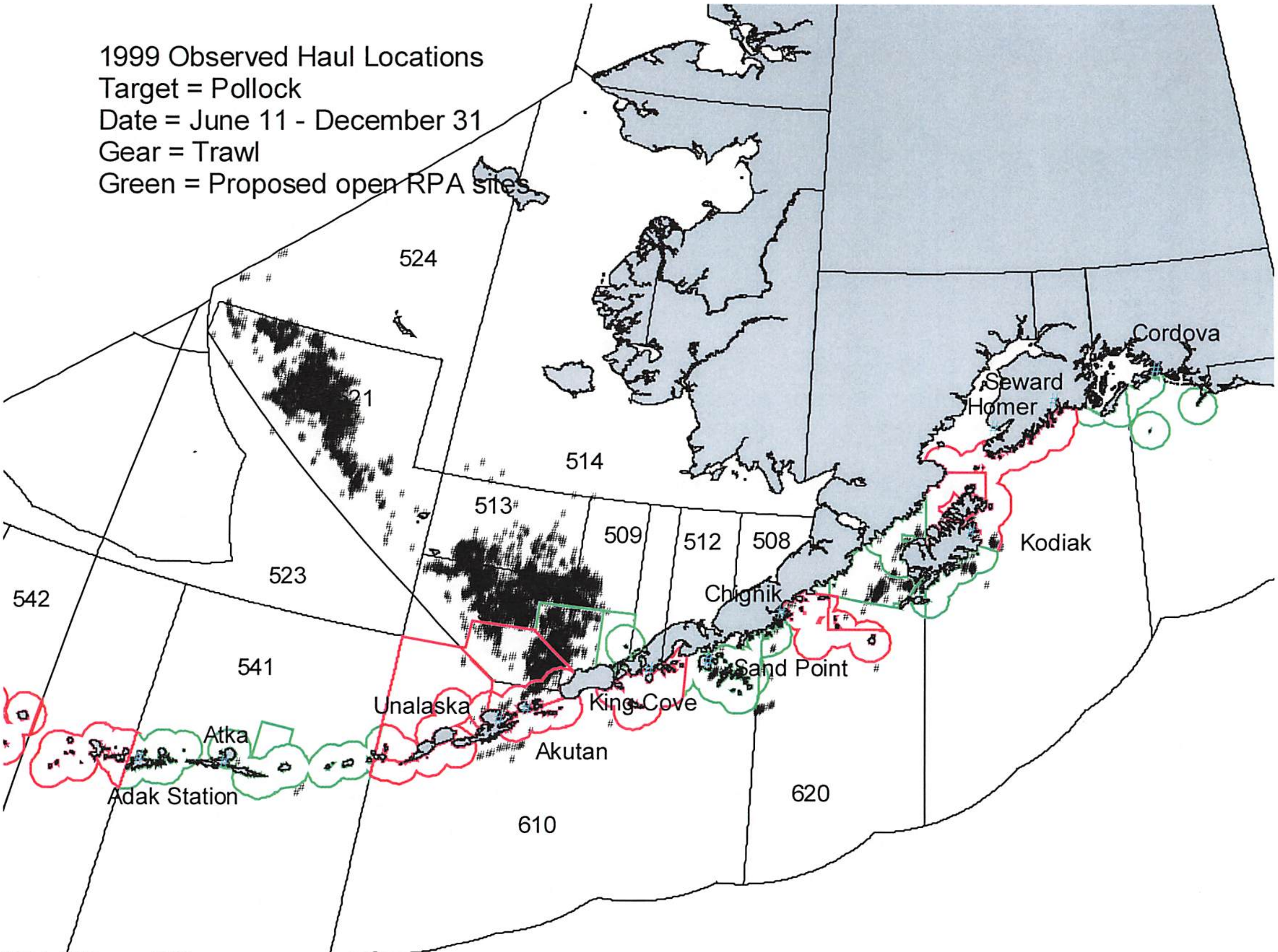

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Gear = Trawl
Green = Proposed open RPA sites
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1999 Observed Haul Locations
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Gear = Trawl
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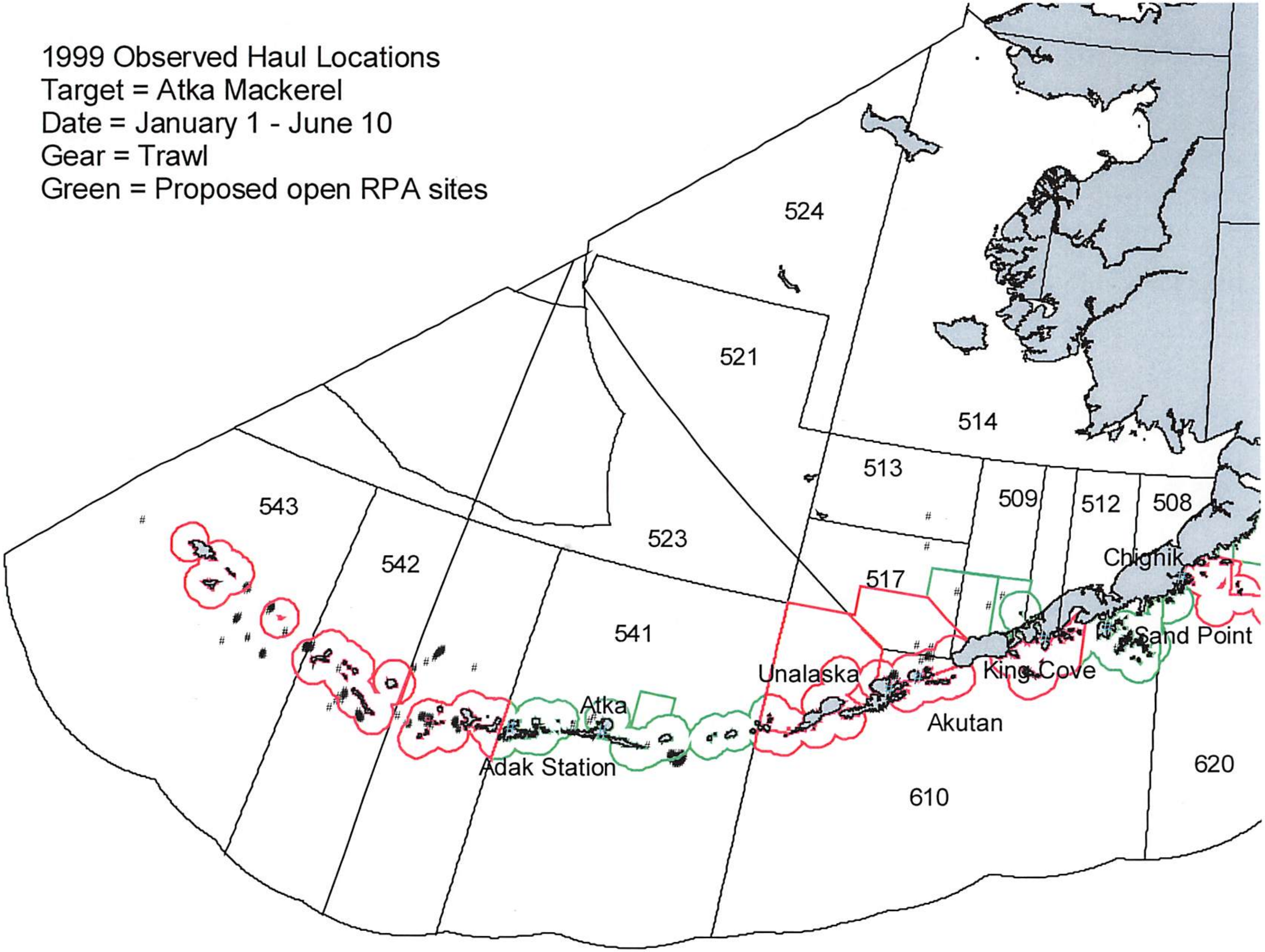

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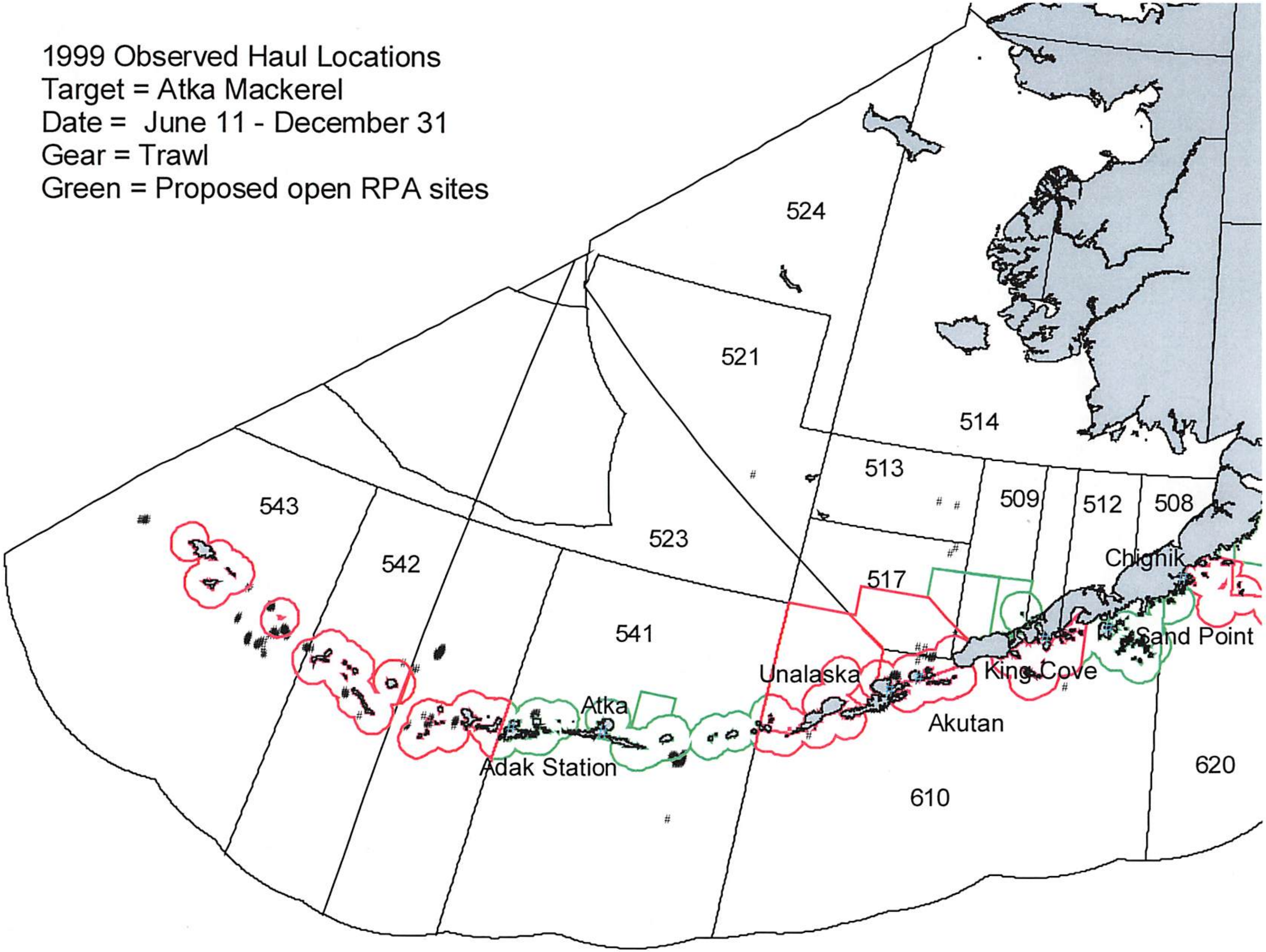

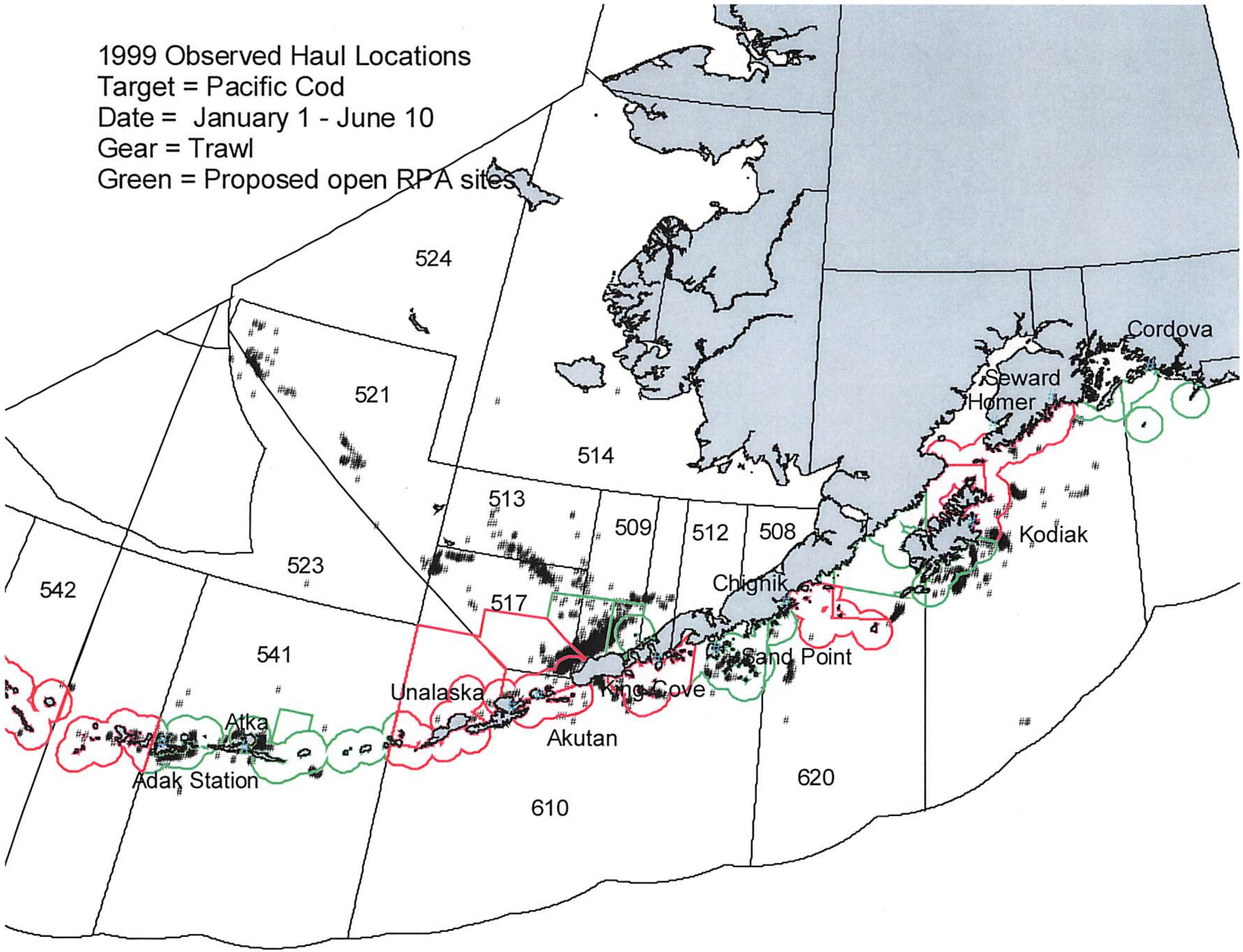
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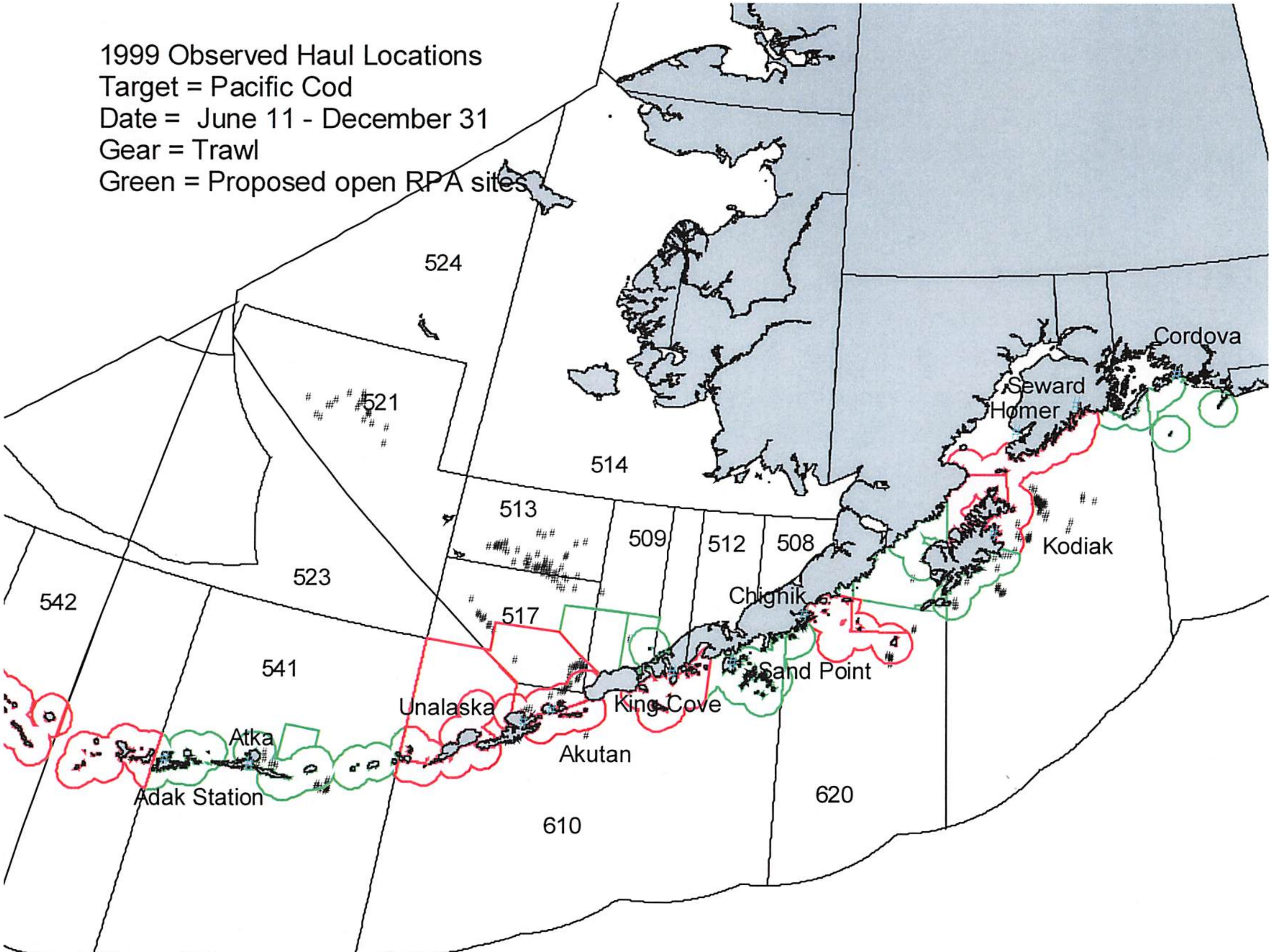
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Gear = Trawl
Green = Proposed open RPA sites
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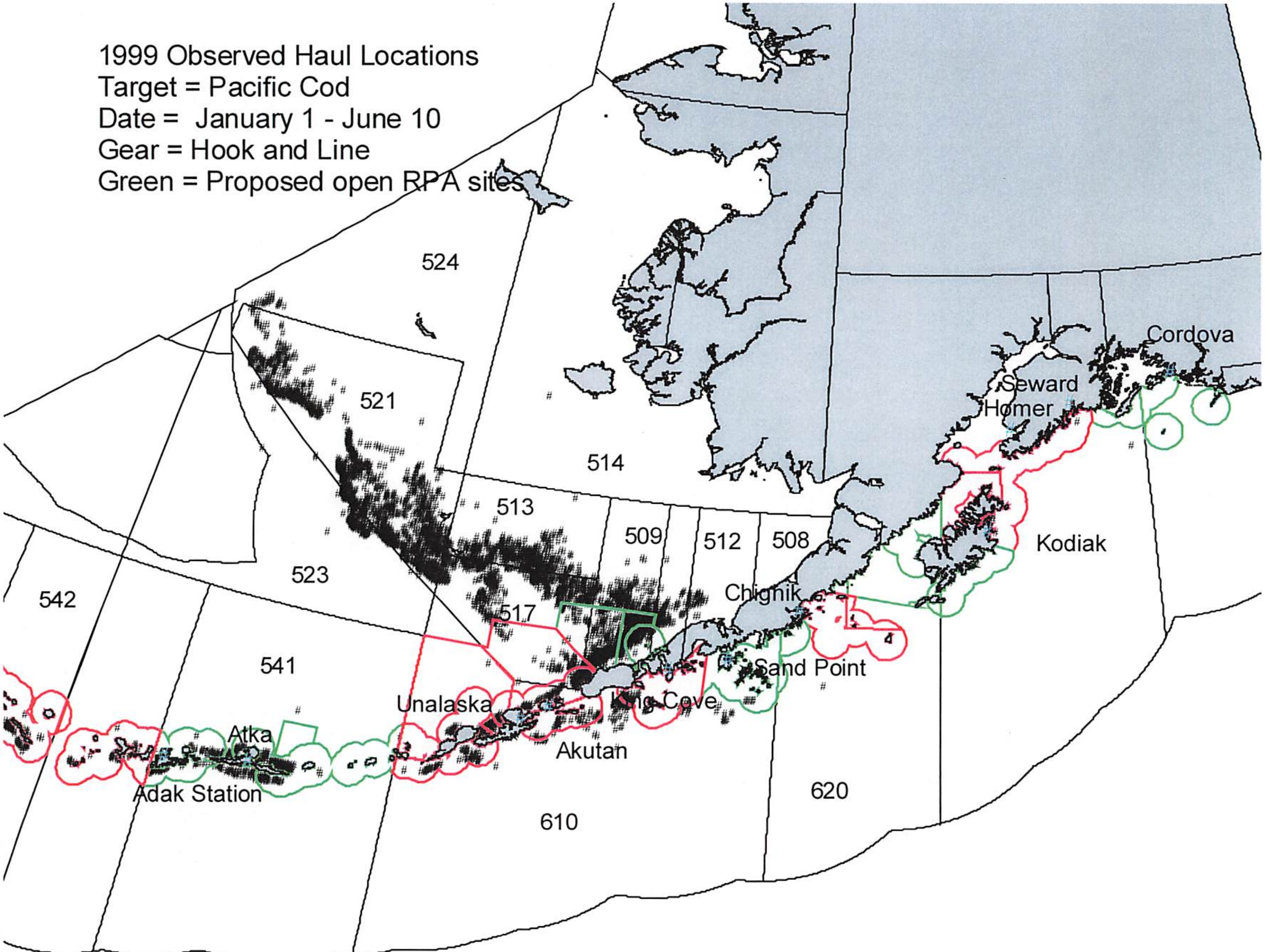
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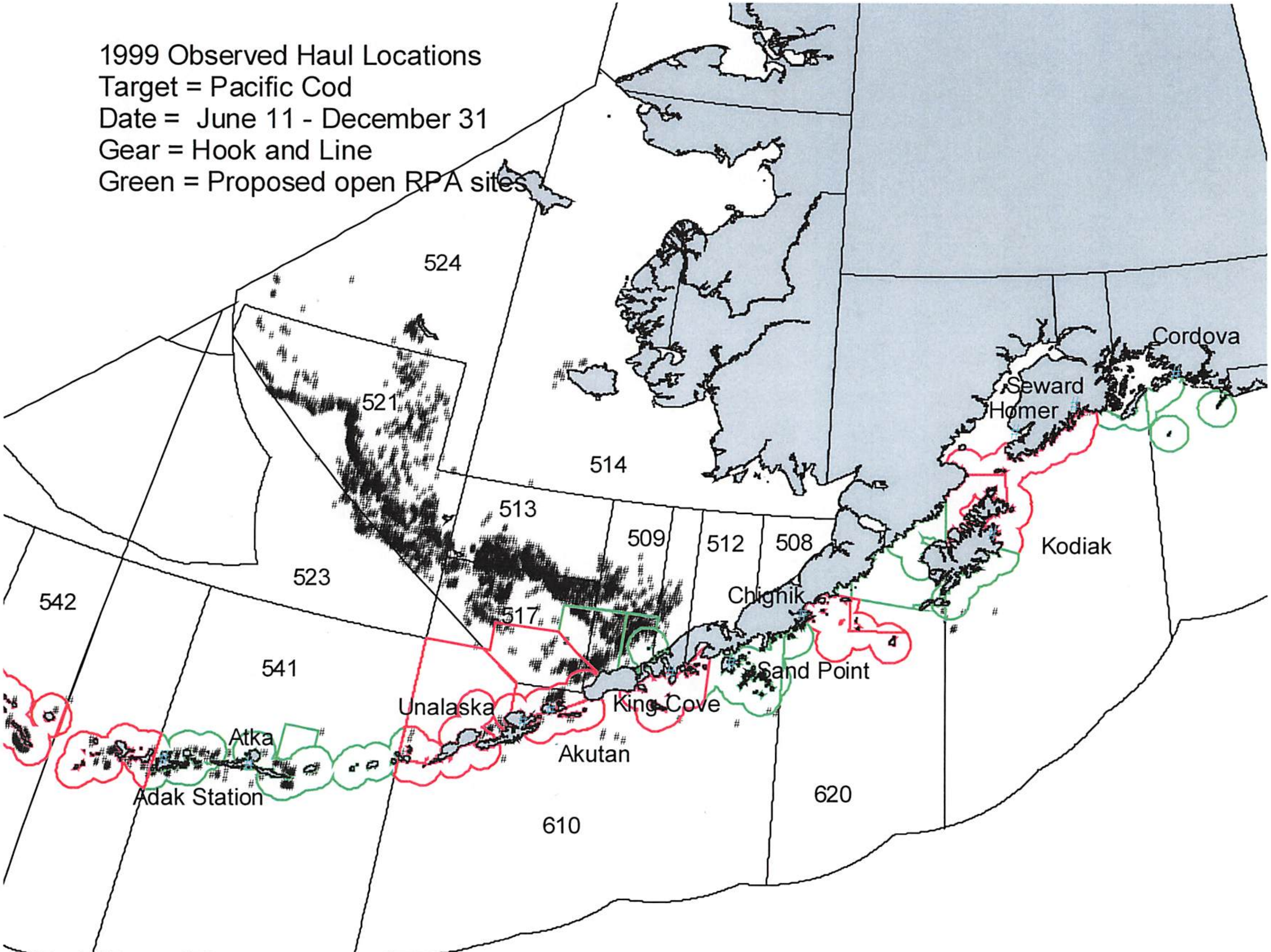
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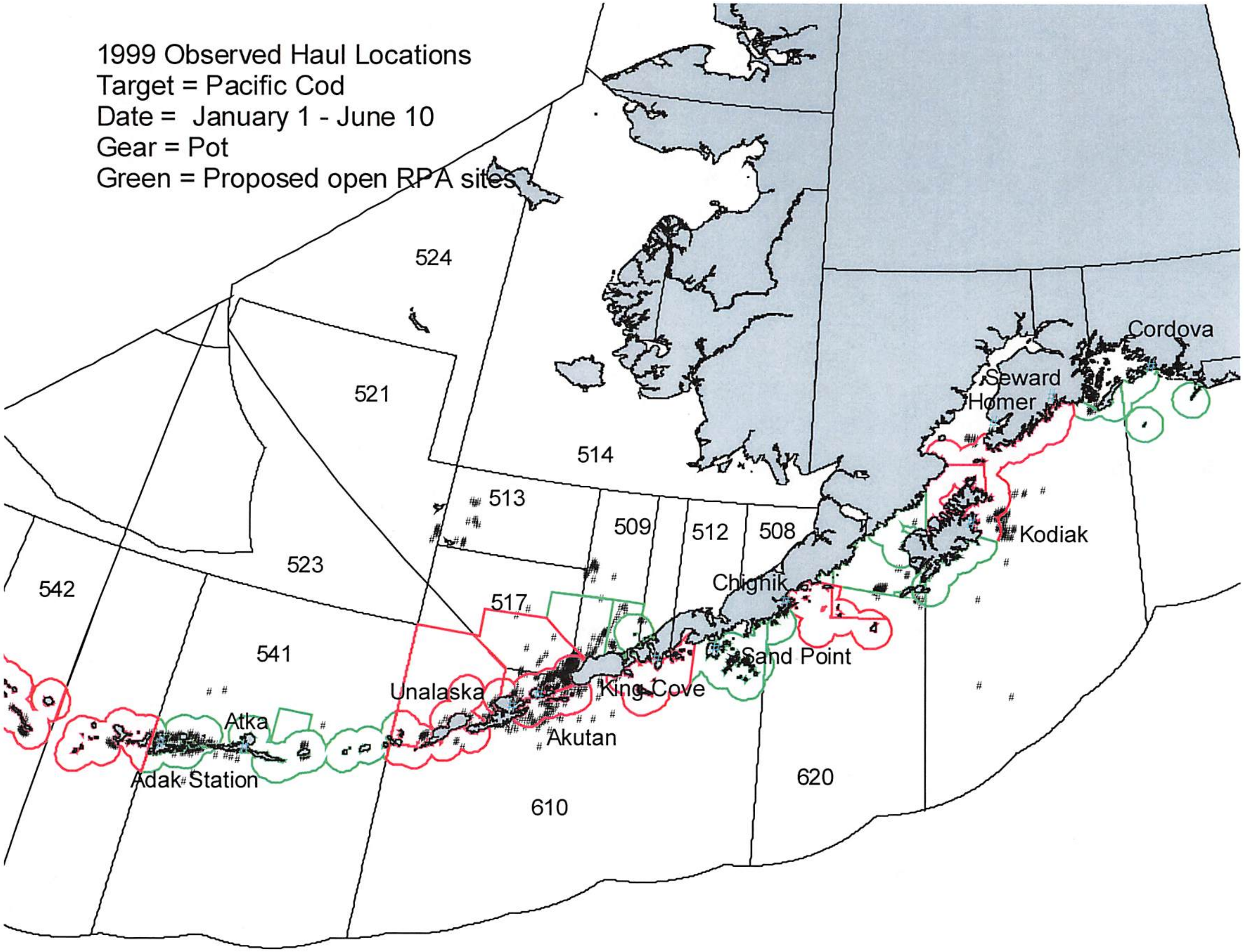

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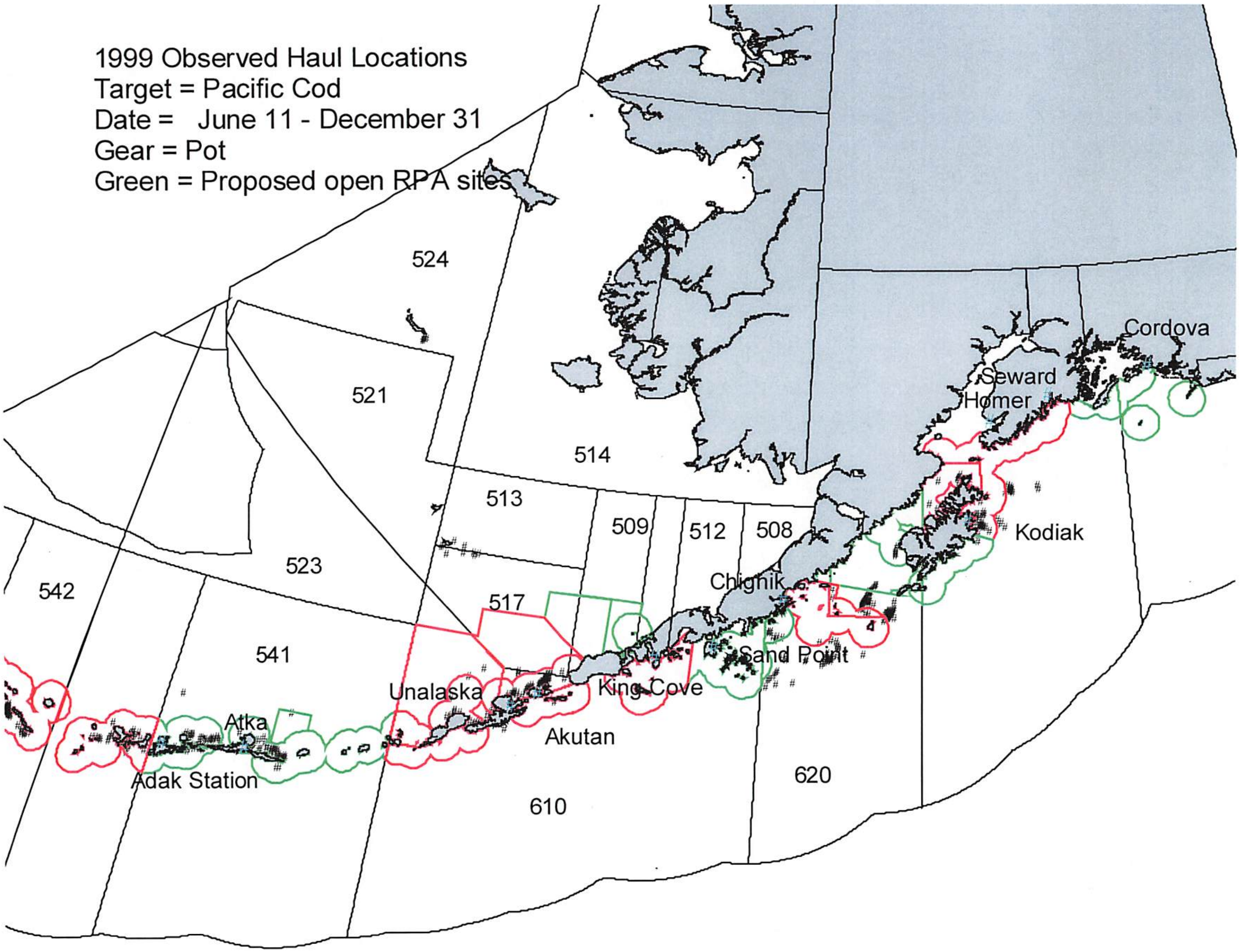
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Date = June 11 - December 31
Gear = Pot
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ADFG

Summary of the Second meeting of the Stakeholder Panel on Steller Sea Lions and Pacific Cod Fishing EA/RIR and State Policy on ESA Actions.

October 3, 2000
Sitka, Alaska

Staff: Kevin Duffy & Earl Krygier

Stakeholders:
Fred Yeck
Joe Plesha
Terry Schaff
Jay Stinson <Al Birch sat as one time alternate>
Dick Jacobson
Michelle Ridgeway
Jerry Bongdon <Jeff Stephan sat as one time alternate>

Kevin Duffy outlined the roll of the Governor's Steller Sea Lion (SSL) Restoration Team: They would focus on (1) ways in which fisheries could occur within Critical Habitat and not impact SSL recovery; and (2) help define research that would help resolve the unanswered questions in this conflict (i.e. do some or all fisheries impact the ability of SSLs to recover?). The second meeting of the Stakeholder Panel reviewed and commented on the "Council Action on Steller Sea Lion/Pacific Cod Interactions" (September 11, 2000 Final Draft). This material was the final draft Council motion (AGENDA Item C-1(a) October 2000 NPFMC) that added additional alternatives to the proposed EA/RIR that analyzed alternatives to minimize possible competitive interactions between Pacific cod fisheries and SSLs. The following is a summary of that discussion.

Comments on P. 1. Alternatives for splitting the season P. cod TAC in the GOA

It was noted that longline gear has a 350 mt halibut bycatch cap. Longliners will be disadvantaged if their P. cod season is split. The reason is that if they fish the first season and then turn to other directed species where they will likely hit the halibut cap and thus be unable to prosecute their 2nd P. cod season.

(In Gulf only) Processors want product throughout the season. Two seasons pose problems for the CGOA. Cod are very spread out during the summer season. If cod cannot be taken when they are aggregated, vessels and processors lose financially. Trawl fisheries receive maximum economic benefit when vessels first trawl for pollock and then switch to P. cod when the milt is firm.

There is also a concern over the bycatch of pollock and salmon, the timing of which differ between the CGOA and the WGOA. With an "A-Season" split, bycatch of salmon would go up early in the season but decrease by May. In the WGOA no trawl cod are available in the fall, because by September the fish are spread out too much for a successful trawl fishery.

Clearly many variables dictate how the season proceeds. Some members thought there may be different ways to look at a split. For example, 2 shorter seasons within January 1 - May 15. But small TAC's can be extremely difficult from a management perspective.

Option C: 1 & 2

When considering alternatives under Option C, panel members felt that research needed to be conducted to validate the underlying assumptions and proposed alternatives. Since the scientific link between fishery/SSL impacts are not known, and distribution of fish stocks are defined by summer surveys, research plans must focus on these unknowns. Most panel members felt that the sooner we can get winter biomass surveys going, the better. Some questioned whether new federal dollars were available to expand the ADF&G Bottom Trawl Survey from the summer into a fall and winter surveys with the R/V Resolution. It was suggested that additional survey work with the Resolution should occur in October and during the peak fishing periods (end of February/early March). It was asked whether we wanted to look at critical habitat when cod aggregations are at their lowest or at their highest?

Under Option 2 it was suggested that pots should be included as a safe option within 0-3 nmi from rookeries.

It was noted that this federal action could have a dramatic impact inside of state waters. There are 62 extra vessels (from 60-120 ft) that qualify to fish under the LLP in the Western GOA parallel fishery. In addition, any of the Bering Sea pot vessels could fish State waters. It was suggested that the BOF may want to look at 60 pot limits so that localized depletions are not a result of LLP spill over in state waters. Others argue that a 60 pot limit for cod are not economical, even for smaller vessels. But that any state water pot limit must include any pots that are concurrently fished in federal waters, i.e. – any pots they control!

In reviewing the motion, members felt that the effect of rolling or not rolling over the annual TAC between seasonal apportionments was critical. The concept of no rollover of TAC from one season to another was discussed by Council. Panel members felt that NMFS should explain if Alternatives A & B include a rollover.

Some panel members felt that the 60' trawl vessel restriction should be put back in under Option 2. Other panel members stated that eliminating vessels > 80 ft would eliminate 80% of the cod and pollock production (compared to last year) within 20 miles.

Option 1: Alternatives for splitting the season P. cod TAC in the BSAI

It was noted that the Draft EA did an inadequate job of evaluating the impacts on the processing industry, particularly the shore-based facilities. Shoreside investments were made under the scenario that processing would occur at least at a scale that would keep plants in production. Some of the alternatives in both the BSAI and GOA would so reduce deliveries as to make it financially impossible to operate crews and plants at a profit. The plants are not likely to not stay open for small amounts of product, because the cost to "clean" (meet EPA/DEC standards) a plant is too high for pulse fisheries. This obviously impacts small coastal communities that rely on these operations for their livelihood. NMFS' ESA approach lacks a useful socioeconomic study that evaluates such restrictive management impacts on Alaskan communities. It was questioned whether it is possible to show (before it happens) that "x" number of processors will likely go away as a result of such protective measures?

While it was noted that the rate of extraction of SSL food (pollock/P. cod) was the issue NMFS' alternatives were trying to address, members noted that there were no clear scientific connection between cod fisheries and SSLs.

Page 4, items 6 & 7

There was concern with the quality of the SSL data used to develop fishery restrictions. It was noted that the most recent summer survey on SSLs occurred in June, where only 3 days of clear weather were available for accurate surveys.

Page 4 Option 2 (Bering Sea East of Seguam Pass). Suggested that in 3-10 nmi range that the Council consider 60-75-100 pots as alternate options. The point being that a restriction of 60 pots for large vessels may be similar to putting trawlers 20 miles offshore.

Page 5, Option B

Some members felt that more options were needed under this alternative. Such as a new Option 3: "may consider operational dependence within CH by gear type" and that the costs to the communities and the State must be considered. Some thought that the historical gear shares needed to be maintained.

It was suggested that as gear types move out of one area into another that NMFS should evaluate changing levels of bycatch of salmon, crab and halibut. Should the new proposed changes increase bycatch rates? What are the adverse impacts from such proposed changes?

C:/SSLissues/StakeholderMin2.doc

A DFG

Minutes of the First Meeting of the Alaska Steller Sea Lion Restoration Team, November 20, 2000

Background

In a Press Release dated September 11, 2000, Governor Knowles announced the formation of a state Sea Lion Restoration Team of *"scientists and stakeholders to develop an alternative management strategy for protecting the Steller sea lions that allows sustainable fishing to continue."* He outlined three elements of their mission: *"First, work to restore healthy, sustainable populations of Steller sea lions so they can be removed from the federal threatened species list; second, promote scientific research into the cause of sea lion population declines; and third, employ the principle of adaptive management."*

Participants

The initial meeting of the Alaska Steller Sea Lion Restoration Team (ASSLRT) was held in Anchorage on November 20, 2000. All members of team were present and included: C. Morgen Crow – a representative (executive director) of the CDQ group, Coastal Villages Region Fund, Jay Stinson – a trawl fisherman from Kodiak, Michelle Ridgway – a marine ecological consultant and board member of the Alaska Marine Conservation Council, Kate Wynne – a marine mammal biologist with the University of Alaska Sea Grant Program, Gordon Kruse (chair) – a marine fishery scientist with the Alaska Department of Fish and Game (ADF&G), Bob Small – the marine mammals coordinator with ADF&G, Ken Pitcher – a marine mammal biologist with ADF&G, Lorrie Rea – a marine mammal biologist with ADF&G, Denby Lloyd – the westward regional supervisor with ADF&G, and Earl Krygier – the extended jurisdiction coordinator with ADF&G. Denby Lloyd chaired the first half of the meeting, and then passed the chair to Gordon Kruse.

Deliberations

Denby Lloyd chaired the morning session. A draft agenda was approved. For most of the morning, the team discussed the purpose and scope of the team's charge. They reviewed the team's knowledge of the issues surrounding the decline of Steller Sea Lions (SSL). The team discussed the possibility that nutritional limitation was responsible for the original decline through the 1980s, whereas other cumulative factors may have had increased influence on more recent population trends. The team discussed a predator pit hypothesis, junk food hypothesis, localized depletion, effects of vessel noise, entanglement, subsistence harvest, disease, pollutants, and other factors. The team discussed the idea that reduced juvenile survival in the western population was the major demographic factor responsible for the decline rather than decreased reproduction. Discussions included evidence for reduced SSL growth in the 1980s versus 1970s and contrasting research findings among SSL in Southeast Alaska (SE) versus the central and western Gulf of Alaska. The team discussed current priority research on nutritional stress, and some potential needed areas of research were briefly discussed, such as the need to continue independent DNA studies for use in stock assessment and stock separation, nutritional limitation, and population dynamics and ecological studies.

Other questions raised by the team included: Do relationships exist between changes in SSL, forage fishes (capelin, herring, etc.), and species like pollock and cod? Have relative densities of fish and SSL changed, both pre and post-recent decline, and between the SE and Western Alaska stocks of SSL? Do we have any knowledge about how fish schools disperse under various fishing pressure and/or gear types or in response to vessel noise? What are the impacts of particular management schemes, and what are the ramifications of concentrated effort in state waters if fishing in federal waters is substantially restricted?

In the afternoon session, Denby passed the chair to Gordon Kruse. The team focused on the following activities: (1) drafting a ASSLRT mission statement; (2) developing a list of team activities; (3) planning a schedule for providing prompt review and comment to the ADF&G Commissioner on the BiOp; (4) preparing a list of documents for consideration by the team in advance of the next meeting; (5) identifying primary topics for the next meeting; and (6) scheduling of the next meeting.

The team drafted the following mission statement:

"The purpose of the Alaska Steller Sea Lion Restoration Team is to promote the recovery of SSL populations while sustaining viable commercial fisheries in Alaska. Specifically, we will (1) review the justification of fishery restrictions to protect and restore SSL, and (2) recommend research priorities and adaptive management strategies designed to identify those factors inhibiting the recovery of the endangered western stock of SSL and provide increased understanding of fishery and SSL interactions."

The team developed a list of future action items:

- Prepare a concise synopsis of SSL declines, including a chronology of potential causes/correlates during the earlier and most recent phases of the declines
- Review the soon-to-be-released NMFS Biological Opinion (BiOp) on SSL and fisheries, as well as associated recommendations by the North Pacific Fishery Management Council (NPFMC)
- Prepare an overview of ongoing research on SSL and associated fisheries interactions and unpublished findings from new research activities, especially imminent research that may not appear in the BiOp
- Identify and recommend new research priorities on SSL and fisheries interactions that are needed to evaluate the SSL issue and consider the funding levels associated with SSL-related research
- Identify potential opportunities for acquiring more comprehensive data sets on research needs via fishers, subsistence hunters, U.S. Coast Guard and others
- Develop management recommendations, primarily experimental and adaptive, for federal (NPFMC) and state (Board of Fisheries, BOF) consideration

- Review current definitions of SSL Critical Habitat (CH) including the history of development, data used for the determinations, and what is considered "critical" to SSL
- Review the SSL endangered and threatened species determinations within the context of the ESA and within the prospects of changes in carrying capacity

The team identified the following tasks to be of highest priority:

1) Review NMFS' 11/30 BiOp and recent Council actions (all team members) – this would be the highest priority, and will be a major topic of the second ASSLRT meeting;
2) Review SSL CH definitions and designations. The team discussed that it will be necessary to review CH in conjunction with the BiOp review;
3) Draft a written synopsis of the decline and chronology of potential causes/correlates – to be prepared in advance of the second ASSLRT meeting (Ken);
4) Prepare a brief review of imminent research findings and current research that ADF&G, NMFS, the Marine Mammal Consortium, and Sea Life Center and others are working on or "in press" – to be prepared near the time of the second ASSLRT meeting (SSL – Ken and fish studies – Gordon); and
5) Subsequent priorities will be to recommend (1) future research priorities, and (2) potential experimental or adaptive management approaches.

The team developed a list of reference documents for consideration in future deliberations and identified a team member (in parentheses) who will make the documents available:

- Endangered Species Act (Gordon)
- State of Alaska fisheries summary report (Gordon)
- Final (1992) Recovery Plan for SSL (Ken provided)
- Panel recommendations from an experimental design workshop on testing the efficacy of SSL no-trawl fishery exclusion zones in Alaska (1998) (Lorrie provided)
- NMFS 11/30 BiOp (Pending, Gordon or Earl will make available)
- Experimental Management Advice (Bob)
- Wallace's (1999) review of the SSL Recovery Program (Earl provided)
- GOA and BS/AI Groundfish FMP Summaries (Michelle; also available at NPFMC website: http://www.fakr.noaa.gov/npfmc/)
- Summary of the RFRPAs (1998) (NMFS website under reconstruction; new location to be provided soon)
- Ecosystem Chapter of the Council's 2000 SAFE (Michelle; also available at NPFMC website: http://www.fakr.noaa.gov/npfmc/)
- Federal register – proposed and final rule of SSL critical habitats including rookeries, important haulouts, and critical foraging areas (Kate)

The team scheduled the next ASSLRT meeting for December 15 in Anchorage, where the team will focus on the BiOp and a review of SSL CH. In advance of the meeting, a synopsis of the SSL decline and associated factors will be prepared by Ken. Around the time of the meeting, Ken and Gordon will prepare a brief summary of ongoing research on SSL and fishery interactions. Team members are advised to purchase their tickets early (preferably non-refundable tickets if they are committed to attending) to help stretch the travel budget. Both Earl Krygier and Bob Small will be unavailable to participate in the next meeting. Jeff Hartman will be requested to participate in Earl's stead to recap recent NPFMC actions on SSL issues.

Post-meeting Note from the Chair

Meetings of the Alaska Steller Sea Lion Restoration Team are work sessions. All meeting minutes will be distributed to the public upon request, and comments are welcomed. In conjunction with routine NPFMC meetings, the state also convenes a Stakeholders Meeting as a primary venue to seek public dialogue on sea lion issues. Michelle Ridgway, Jay Stinson, and Earl Krygier participate on both the Stakeholder Panel and ASSLRT. In their dual capacities, they will distribute ASSLRT minutes to the Stakeholder Panel, and in turn they will disseminate Stakeholder Panel minutes and stakeholder input to ASSLRT.

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Steller Sea Lions and Fisheries

Community Update #1
December 7, 2000

Background

July 20, 2000	The U.S. District Court ruled that the scientific analysis (Biological Opinion) prepared by the National Marine Fisheries Service (NMFS) did not adequately protect Steller sea lions and their critical habitat. In response, the judge prohibited all groundfish trawling within Steller sea lion critical habitat (20 nautical mile buffers around rookeries and haulout sites, plus foraging habitat) in the Bering Sea/Aleutian Islands and Gulf of Alaska west of 144 W. longitude until further court order. The judge also ordered NMFS to write a new Biological Opinion.
November 30, 2000	The National Marine Fisheries Service (NMFS) released the new Biological Opinion (BiOp) that concluded that food stress continues to be the agency's lead hypothesis for why sea lions are not recovering. The agency found that the Bering Sea/Aleutian Island (BSAI) and Gulf of Alaska (GOA) pollock, Atka mackerel, and Pacific cod fisheries are jeopardizing the "recovery of the Steller sea lion." An accompanying management measure called an RPA (Reasonable and Prudent Action--a legal term) severely limits both fixed gear and trawl fishing in the 2001 fishery and potentially beyond.
December 4, 2000	The North Pacific Fishery Management Council meeting began. It is scheduled to end on December 12th.
December 5, 2000	The Court acknowledged completion of the BiOp and dissolved the trawl prohibition. The Court did not rule on the adequacy of the BiOp or the fairness of the RPA; it will only do that if the BiOp and/or RPA is appealed.

AMCC's Perspective

It's good to have the scientific analysis on the street so everyone can see the information and the basis for Steller sea lion conservation.

But we reject the management plan (RPA) for sea lions because it does not serve conservation and it places tremendous and unnecessary impact on the ability of coastal communities to participate in fisheries. The dual goal of meeting conservation and community needs is thwarted by the RPA in these ways:

- The RPA has allocation consequences that will increase bycatch, increase habitat impacts, and favor offshore trawl vessels over less intensive gears and Alaska's community-based fleets.

- The RPA is a broad-brush approach that doesn't take into account the effects of different gears and fishing practices on harvest rates (which impact the ability of Steller sea lions to find fish to eat), and is likely to actually *increase* bycatch and habitat impacts.
- The RPA is disproportionately harmful to fixed gear fishermen (fishing practices which have the lowest harvest rates, lower bycatch, and light impact on marine habitat). Previous RPAs have not limited fixed-gear, community-based fishermen.
    - For some communities, the RPA prohibits all participation in the federal cod fishery by fixed gear as well as trawl vessels (Homer/Kachemak Bay, Chignik, King Cove, Unalaska/Akutan).
    - In other communities, participation by jigs, longlines and pots are greatly reduced.
- The allocative consequences of the RPA take fisheries management in the exact opposite direction of what is good for coastal communities and long-term fisheries conservation (minimizing bycatch, slowing down the race for fish, and protecting habitat). Fisheries management should encourage – not take away – clean, low impact fishing opportunities.
- NMFS put together this RPA without the benefit of a public process. This is a bad precedent-- the American Fisheries Act was the last time this type of behind-closed-doors decision-making was done regarding Alaska fisheries.

The Endangered Species Act is a pillar of our nation's conservation law. But this RPA abuses the principles in the law and threatens the ability of people working together to improve fisheries management overall.

NMFS had a year to prepare the BiOp, but left the RPA until the very end and spent only a few weeks in developing management measures. The RPA shows major flaws as a result.

What You Can Do

Contact Senator Stevens and Governor Knowles and tell them we need a brand new management plan to address sea lion recovery. Development of the new plan should involve:

- Public participation-- fishery managers should set a "time out" for six months to allow better long-term solutions to be developed, with the participation of fishermen and coastal communities.
- Analysis to show the effects of different gears and practices on harvest rates, bycatch and habitat and incorporate those differences into the management measure.
- Other ways to control fishing rates and improve conditions for sea lions that do not involve closing areas to whole communities and clean fishing (such as trip limits, gear limits, vessel rotation, gear conversion).
- AMCC strongly supports Steller sea lion and ecosystem conservation, but we do not believe this RPA accomplishes that goal.

The Honorable Ted Stevens United States Senate Washington, DC 20510 FAX: (202) 225-2354 senator_stevens@stevens.senate.gov	The Honorable Tony Knowles P.O. Box 110001 Juneau, AK 99811-0001 FAX: (907) 465-3532 Office_of_the_Governor@gov.state.ak.us

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TESTIMONY TO NPFMC ON STELLER SEA LION ISSUES
December 8, 2000
Anchorage, Alaska

- The ACC, representing the owners and operators of 52 Bering Sea crab pot vessels, wishes to provide comments for the administrative record supporting the findings and recommendations of the NPFMC Advisory Panel in regards to the National Marine Fisheries Service Biological Opinion relating to Steller sea lions.

- There are approximately 45 Bering Sea pot vessels that regularly participate in the harvest of Pacific cod in the Bering Sea and Aleutian Islands. These vessels harvest 9% of the total TAC, which last year amounted to almost 17,000 metric tons. The vessels are economically dependent on the fishery for a significant portion of their annual gross revenue. Almost 80% of the fleet's historic catch normally occurs in critical habitat, CH-RFRPA Area 8, as noted in Figure 9.1a. of the Biological Opinion.

- Establishment of the Area 8 closure area will quite likely foreclose the fishery for most of the pot vessels, as it closes off most of the most productive cod fishing grounds adjacent to the ports of Akutan and Dutch Harbor. This is a significant problem, as the pot vessels fishing and travel time to return to port is limited to 60 hours. Closure of Area 8 will force not only pot vessels, but trawl vessels into Area 7, a longer distance from the landing ports.

- It is my understanding from public testimony and discussion of the Steller sea lion issues in the Advisory Panel yesterday, that the NMFS, in formulating the CH-RFRPA closure areas, did not consider the conservation effects of displacing fishing effort into other areas and did not establish the scientific rationale for the boundaries of the closure areas. In particular, the agency did not take into consideration the potential impacts of increasing prohibited species bycatch (PSC), in the areas where the displaced fishing effort will go, as a result of the establishment of the closed areas. The ACC participated in a scoping session with the NMFS this past summer and raised these issues, that will soon have a drastic effect on the pot vessels and increased crab bycatch.

- The cumulative effects of the CH-RFRPA closed areas, 8 and 9, in the Bering Sea will push pot and trawl vessels together into Area 7, (if pot vessels decide to fish cod at all next year), create gear conflicts, and result in high bycatches of already depressed bairdi and king crab.

Arni Thomson, Executive Director

Comment on Page 253 of the

November 30, 2000 Biological Opinion

Prepared by:
dave fraser

Submitted by:

High Seas Catchers' Co-op

120 Lakeside Avenue, Suite 230
Seattle, Washington 98122
Phone 206-399-0742
Fax 206-860-1418

Date:
December 8, 2000

To:
National Marine Fisheries Service
North Pacific Fisheries Management Council

BiOp Jeopardy

This word occurs 29 times in the 1st 28 pages of the BiOp.

Answer:
What is the word "MAY?"

This word occurs 42 times in the BiOp.

Answer:
What is the word "BELIEVE?"

<u>BiOp Trivia</u>

What is the 1st definition of "Believe" in Webster's Online Dictionary?

believe	Dictionary

Main Entry: **be·lieve**
Pronunciation: b&-'lEv
Function: *verb*
Inflected Form(s): **be·lieved; be·liev·ing**
Etymology: Middle English *beleven,* from Old English *belEfan,* from *be-* + *lyfan, lEfan* to allow, believe; akin to Old High German *gilouben* to believe, Old English *lEof* dear -- more at <u>LOVE</u>
Date: before 12th century

intransitive senses

<u>1 a : to have a firm religious faith</u>

b : to accept as true, genuine, or real <ideals we *believe* in> <*believes* in ghosts>
2 : to have a firm conviction as to the goodness, efficacy, or ability of something <*believe* in exercise>
3 : to hold an opinion **:** <u>THINK</u> <I *believe* so>

transitive senses

1 a : to consider to be true or honest <*believe* the reports> <you wouldn't *believe* how long it took>
b : to accept the word or evidence of <I *believe* you> <couldn't *believe* my ears>
2 : to hold as an opinion **:** <u>SUPPOSE</u> <I *believe* it will rain soon>

The BiOp Credo

We believe that:

- pups that are being weaned and juvenile sea lions that have been weaned are dying

- in the face of competition from the groundfish fisheries when

- they are unable to locate prey in the densities they need to sustain themselves.

This reduces the population size of Steller sea lions and effectively reduces their reproductive rate.

Forever and Ever, Amen.

November 30, 2000 Biological Opinion
Book 6 - Effects of the Federal Action
Chapter 6.6.1 Sea Lions –Page 253 verse 24-28

Footnote:
"MAY" occurs 27 times in the 3 pages of Subsection 6.6.1

BiOp Deconstruction

We believe that:

See Webster's

intransitive senses
to have a firm religious faith
to accept as true, genuine, or real
to have a firm conviction as to the goodness, efficacy, or ability of something
to hold an opinion
transitive senses
to consider to be true or honest
to accept the word or evidence of

pups that are being weaned and juvenile sea lions that have been weaned are dying

The 1st part of this tenant seems to be based on evidence - "general scientific agreement" that the decline of Steller sea lions in the 1990s resulted primarily from declines in the survival of juvenile Steller sea lions."

The 2nd part of this tenant seems to be accepted, but without examination of the implications. Are they "dying" (of starvation) or being killed (by predators)?

Has a population model been developed and made available to the SSC that looks at the demographics of the population and projects changes in the population based on those demographics?

<u>BiOp Deconstruction – continued</u>

in the face of <u>competition</u> from the groundfish fisheries

Is there overlap, in time, space, size, and depth?

Is the competition limiting?

If competition is not limiting, and overlap is limited, is this a matter of correlation or causation?

Has any new data been presented in this BiOp to examine the issue on a case by case basis?

This <u>firm conviction</u> seems to rest largely on <u>faith</u>.

when they are unable to locate <u>prey in the densities they need</u> to sustain themselves.

Is the "Localized Depletion" theory based on any peer reviewed published data?

If localized depletion does occur, what is the temporal duration of its effect?

What density of prey is necessary to sustain a juvenile sea lion? What species and sizes of prey do juveniles consume? Is it the same as adults?

Again, this <u>firm conviction</u> seems to rest largely on <u>faith</u>.

BiOp Deconstruction – concluded

The BiOp's Credo leads to the following conclusion:

This reduces the population size of Steller sea lions and effectively reduces their reproductive rate.

Is the conclusion (from which it follows that the fishery is the witch and must be burned) based on evidence or faith?

Is it a sloppy syllogism? Or is it an opinion?

Apparently this part of NMFS's Belief is an Opinion

- for while there is also "general scientific agreement" that declines in the survival of juvenile Steller sea lions and lowered reproductive success have a dietary or nutritional component...

The same section 6.6.1 tells us that

- "there is much less agreement on whether fishery-induced changes in the forage base of Steller sea lions have contributed to and continue to contribute to the decline of Steller sea lions."

- and that we reject a strategy of appeasement.

Is the "Monitoring" Design Fundamentally Flawed?

Comparison of Pollock and Groundfish by Block to Sea Lion Counts

From BiOp table 9.6 and SAFE documents

Block	Area	non-pups	pups	all counted sea lions	pollock biomass	groundfish biomass	other forgage fish biomass	ratio: sea lions to pollock tons	ratio: sea lions to groundfish tons
I	GOA	11,541	4,058	15,599	706,000	3,621,000	?	1:45	1:232
	BERING &			6,783	10,060,000	19,099,962	?	1:1483	1:2860
II	Bogoslof	5,133	1,650		300,000	300,000	?		
III	ALEUTIANS	8,513	3,665	12,178	106,000	1,027,818	?	1:9	1:84
I-III total		25,187	9,373	34,560	11,172,000	24,048,780	?	1:323	1:696
IV	SEO/EYAK	20,000	3,700	23,700	28,000	?	?	1:1	?

Comparison of Western and Eastern Sea Lion Pup and Non-pup Counts

From BiOp pages59 and 103

Western stock non pups	25187	ratio
Eastern stock (SEO) nonpups	20000	1:1.3

Western stock pups	9373	ratio
Eastern stock (SEO) pups	3700	1:2.5

NMFS's attempts at appeasement of the Plaintiffs, puts the North Pacific Fishing Community in Jeopardy

To paraphrase German anti-Nazi activist, Pastor Martin Niemöller:

"When Greenpeace attacked the Factory Trawlers I was not a Factory Trawler, therefore I was not concerned.

And when Greenpeace attacked the CV Trawlers, I was not a CV Trawler, and therefore, I was not concerned.

And when Greenpeace attacked the "Big Boats" and the Freezer Longliners , I was not a "Big Boat" owner and I was not concerned.

Then Greenpeace attacked me and the State water fisheries — and there was nobody left to be concerned."

The Advisory Panel's Motion is a unanimous expression that:

- we are all concerned,
- we are ready to speak out,

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON
AT SEATTLE

GREENPEACE, AMERICAN OCEANS CAMPAIGN, and SIERRA CLUB,

Plaintiffs,

v.

NATIONAL MARINE FISHERIES SERVICE, and WILLIAM M. DALEY, in his official capacity as Secretary of the Department of Commerce,

Defendants.

NO. C98-492Z

ORDER

The Court has reviewed the Biological Opinion on the Alaskan groundfish fisheries (BiOp) issued by the National Marine Fisheries Service (NMFS) on November 30, 2000, pursuant to Section 7 of the Endangered Species Act, docket no. 485.

By prior Order dated August 7, 2000 this Court enjoined all commercial groundfish trawl fishing within the waters of the Steller sea lion critical habitat within the Bering Sea/Aleutian Islands and the Gulf of Alaska region west of 144 degrees longitude. See Order, docket no. 428. This injunction became effective on August 8, 2000 at noon Pacific time. Id.

By prior Minute Order, this Court directed the parties to file supplemental briefing discussing the "legal basis for the timing and procedure this Court should implement for dissolving the injunction." See Minute Order, docket no. 445. The Court has reviewed these

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briefs. See Federal Defendants' Supplemental Brief, docket no. 469; Defendant-Intervenors' Supplemental Memorandum, docket no. 470; Plaintiffs' Supplemental Memorandum, docket no. 471. Federal defendants and defendant-intervenors urged the Court to dissolve the injunction immediately upon filing of the new BiOp. Plaintiffs urged the Court to leave the injunction in place until the Court can review and resolve any dispute as to the adequacy of the BiOp.

The decision on whether to dissolve or modify an injunction is within the sound discretion of the trial Court. See e.g. Tracer Research v. National Environmental Services Co., 42 F.3d 1292, 1294 (9th Cir. 1994). The law presumes the BiOp filed on November 30, 2000 is valid. 5 U.S.C. § 706(2). See also Washington Crab Producers, Inc. v. Mosbacher, 924 F.2d 1438, 1441 (9th Cir. 1991).

Accordingly, IT IS HEREBY ORDERED:

(1) The injunction issued by this Court on August 7, 2000 prohibiting all commercial groundfish trawl fishing authorized by the Fishery Management Plans for the Bering Sea/Aleutian Islands and Gulf of Alaska and within the waters of Steller sea lion critical habitat, docket no. 428, is hereby DISSOLVED immediately;

(2) A telephonic status conference is scheduled for Friday, December 8, 2000 at 1:00 p.m.

IT IS SO ORDERED.

DATED this 5th day of December, 2000.

Thomas S. Zilly

THOMAS S. ZILLY
UNITED STATES DISTRICT JUDGE