A Brief History of Bycatch Management Measures for Eastern Bering Sea Groundfish Fisheries

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Introduction

Bycatch management measures instituted for groundfish fisheries of the eastern Bering Sea have focused on reducing the incidental capture and injury of species traditionally harvested by other fisheries. These species include king crab, *Paralithodes* and *Lithodes* spp.; Tanner crab, *Chionoecetes* spp.; Pacific herring, *Clupea harengus pallasi*; Pacific halibut, *Hippoglossus stenolepis*; and Pacific salmon and steelhead trout, *Oncorhynchus* spp. Collectively, these species are called "prohibited species," as they cannot be retained as bycatch in groundfish fisheries and must be discarded with a minimum of injury.

Regulations promulgated in the 1940's and 1950's prohibited taking and retaining these species except by specific gear types. The concept of prohibited species was incorporated into regulations implemented following passage of the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) in 1976, first for controlling foreign fisheries within the U.S. Exclusive Economic Zone, and then for the development of domestic fisheries thereafter. The North Pacific Fishery Management Council (NPFMC) and the National Marine Fisheries Service (NMFS) have enacted many management measures to allocate, control, and reduce the incidental take of prohibited species in groundfish fisheries. This paper provides a historical review of these measures and analysis of their effectiveness.

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Pre-Magnuson Act Era

Prior to enactment of the MFCMA in 1976, fishery management measures in the eastern Bering Sea were implemented through public laws and international agreements. The early regulations applied only to the U.S. 3-mile territorial sea and were administered by the Bureau of Commercial Fisheries through 1959. Thereafter, they were administered by the Alaska Department of Fish and Game when Alaska gained statehood. Prior to 1950, salmon constituted the primary fishery in the Bering Sea; Pacific halibut, sablefish, *Anoplopoma fimbria*; rockfish, *Sebastes* spp.; flatfish, *Pleuronectes* and *Hippoglossoides* spp.; and king crab fisheries developed in the late 1950's. As these fisheries developed, regulations were promulgated to prohibit the harvest of certain species by particular gear types (Table 1). This set the stage for bycatch and allocation disputes among fishermen using the different gear types. These disputes continue to the present day.

The International Convention for High Seas Fisheries of 1959 was the governing treaty for fisheries outside the U.S. territorial sea. It entered into force in June 1953. The Convention established the International North Pacific Fisheries Commission to provide scientific information and recommendations on conservation measures to ensure maximum sustained productivity of fish resources. One of the Convention's new regulatory measures was a provision that Japan (the only foreign fleet active in the eastern Bering Sea at the time) was prohibited from fishing halibut in certain areas and from trawling in the Bristol Bay Pot Sanctuary to minimize interaction with the red king crab, *Paralithodes camtshaticus*, pot fishery (Fig. 1). A more comprehensive review of early fishery management in the North Pacific is provided by Fredin[1].

In 1966, the U.S. congress established a 9-mile contiguous fishery zone adjacent to the 3-mile territorial sea. Bilateral agreements with Japan and the U.S.S.R. were first initiated in 1967, and made biannually thereafter (Fredin[1]). Provisions of the agreements included continuation and expansion of the Bristol Bay Pot Sanctuary, and an array of area closures to prevent foreign fisheries from targeting on Pacific halibut or having gear interactions with domestic fisheries. The 1975 bilateral agreements established the Winter Halibut Savings Area (Fig. 1) in which trawling was prohibited by all vessels from December through March, and a large zone between long. 170° W and 175° W closed to trawling by Japanese vessels. The Pacific halibut stock had declined throughout the 1960's, and the intent of these closures was to reduce bycatch and rebuild the Pacific halibut resource.

Regulated Foreign Fisheries, 1976–84

Passage of the MSFCMA in 1976 ushered in a whole new era of fishery management in the North Pacific. Un-

[1] Fredin, R. A. 1987. History of regulation of Alaska groundfish fisheries. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Northwest Alaska Fish. Cent. Proc. Rep. 87-07, 63 p.

der this Act, the United States declared exclusive management authority over all fish resources out to 200 n.mi., and prohibited fishing by foreign vessels except as authorized under certain conditions. A major goal of the Act was to "Americanize" the fisheries off U.S. coasts. The Act required preparation of fishery management plans (FMP's) to achieve and maintain optimum yield from each fishery in accordance with seven national standards for conservation and management. A preliminary FMP for Bering Sea groundfish fisheries was implemented in 1977 with the objectives of rebuilding depleted groundfish and halibut stocks and preventing overexploitation of healthy stocks. This preliminary plan set up both the pot sanctuary and the winter halibut savings area no-trawl zones.

A FMP for Bering Sea and Aleutian Islands (BSAI) groundfish was formally implemented in 1982. The fisheries at that time were prosecuted primarily by foreign fleets from Japan, U.S.S.R., and the Republic of Korea. The pot sanctuary and halibut savings area were included in the original FMP, but the plan was amended in 1983 to allow domestic trawling within the areas. An overall management goal of the FMP is to minimize prohibited species catch (PSC) while attaining optimum yield of groundfish species. In 1982, the FMP was amended to establish a prohibited species catch limit of 55,250 chinook salmon, *O. tshawytscha*, for foreign trawl fisheries, which were annually allocated among foreign nations. Any nation that exceeded their salmon allocation would be prohibited from fishing in much of the Bering Sea for the remainder of the season. This amendment set a precedent for fleet-wide bycatch limits that trigger area or entire fisheries closures.

In 1983, the FMP was amended to reduce the incidental catch of Pacific halibut (50% reduction), Pacific salmon (75% reduction), and king and Tanner crabs (25% reduction) by the foreign trawl fisheries over a 5-year period. The FMP provided incentives for reaching this goal by allocating supplemental groundfish within a fishing season to nations on the basis of their bycatch performance. The Japanese fleet successfully accomplished bycatch reductions by allocating their bycatch allowance among participating vessels. If a vessel allocation was exceeded for any species, that vessel had to stop fishing unless it purchased unused bycatch shares from other vessels. This system

Table 1. — Time line of management measures to control bycatch of prohibited species in the groundfish fisheries of the Bering Sea and Aleutian Islands area, 1935–97.

Year	Regulation
1935	Trawls prohibited except for shrimp and flounder fishing.
1937	Use of dynamite prohibited.
1938	Use of gillnets prohibited for catching halibut.
1942	Trawls permitted except for salmon and herring fishing.
1944	Use of trawls prohibited for catching halibut.
1948	5-inch minimum mesh size required for trawls.
1959	Trawls prohibited for taking any crab species. Trawling prohibited in Bristol Bay king crab pot sanctuary.
1967	Halibut nursery area closed to halibut fishing. Foreign fisheries prohibited around Fox Islands.
1969	Pribilof Islands area closed to foreign fishing.
1972	Pot gear prohibited for catching halibut.
1973	Use of tangle nets prohibited for catching crab.
1974	Catch quotas established for Japanese groundfish fisheries limit effort.
1975	Catch quotas established for USSR groundfish fisheries. Trawling prohibited in winter halibut savings area and along most of the Aleutian Islands.
1976	Magnuson Act passes, providing national standards and regulations.
1977	Preliminary BSAI Groundfish FMP implemented with several closure areas.
1982	BSAI Groundfish FMP implemented. Chinook salmon bycatch limits established for foreign trawlers.
1983	Halibut, salmon, king crab, and Tanner crab bycatch reduction schedule established for foreign trawling. Domestic trawling allowed in pot sanctuary and Halibut Savings Area.
1984	Further reductions in salmon bycatch limits for foreign trawling. Two million metric ton (t) optimum yield cap on groundfish established.
1987	Bycatch limits and zones established for red king crab, Tanner crab, and halibut taken in domestic and JV flatfish trawl fisheries. Area 512 closed to all trawling year-round.
1989	Bycatch limits for crab and halibut apply to all trawl fisheries. Area 516 closed to trawling seasonally during crab molting period.
1990	New observer program and data reporting system implemented.
1991	VIP established for red king crab and halibut bycatch. Herring Savings Areas established. Season for yellowfin sole fishery changed to May 1.
1992	Hotspot authority granted. VIP expanded for all trawl fisheries. Halibut PSC limits established for BSAI nontrawl fisheries.
1993	Gillnets and seines prohibited for groundfish fishing. Careful release requirements established for halibut bycatch in groundfish longline fisheries. Crab bycatch performance standards set for pelagic trawl fishery.
1994	Council adopts minimum mesh size requirements for trawl codends used in pollock, cod, and rock sole fisheries. Voluntary retention of salmon for food banks allowed. NMFS publishes vessel specific bycatch rates on the Internet.
1995	Chum Salmon Savings Area, Chinook Salmon Savings Area, and Pribilof Islands Habitat Conservation Area established as trawl closure areas. Bottom trawling prohibited in Red King Crab Savings Area established by emergency rule. Halibut and sablefish IFQ program allows retention of halibut in sablefish fisheries.
1996	Red King Crab Savings Area permanently established as year-round trawl closure area.
1997	Nearshore Bristol Bay closed to all trawling year-round. PSC limits for red king crab and Tanner crab reduced. PSC limits for snow crab implemented.

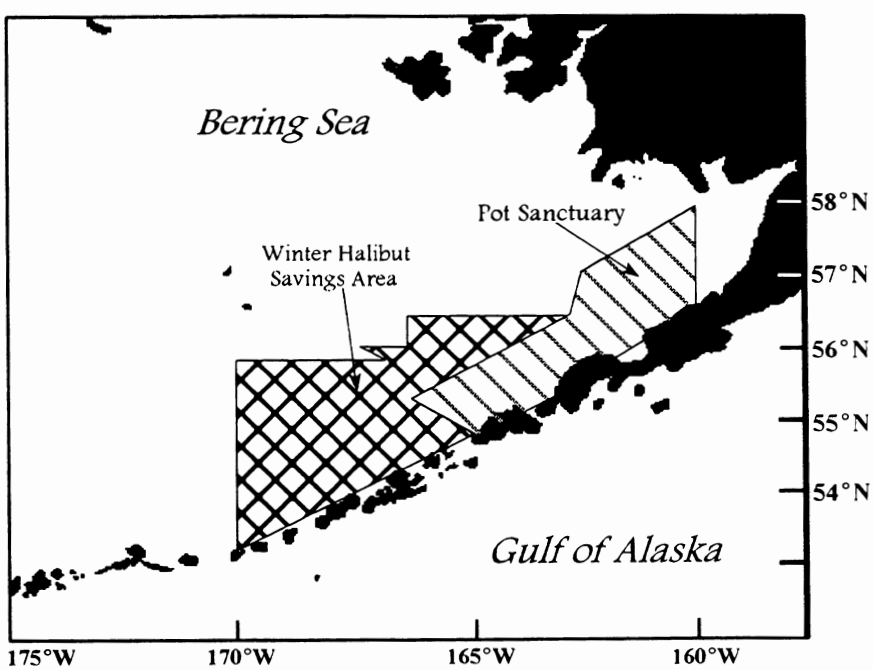

Figure 1. — The Bristol Bay Pot Sanctuary and the Winter Halibut Savings Area.

attained. Like other PSC limits, the herring PSC limit (set at 1% of estimated herring biomass) is apportioned among specified trawl fisheries. If a bycatch allowance is attained, Area 1 closes 15 June to 1 July, Area 2 closes from 1 July to 15 August, and Area 3 closes during the winter months (1 September through 1 March) for specified fisheries.

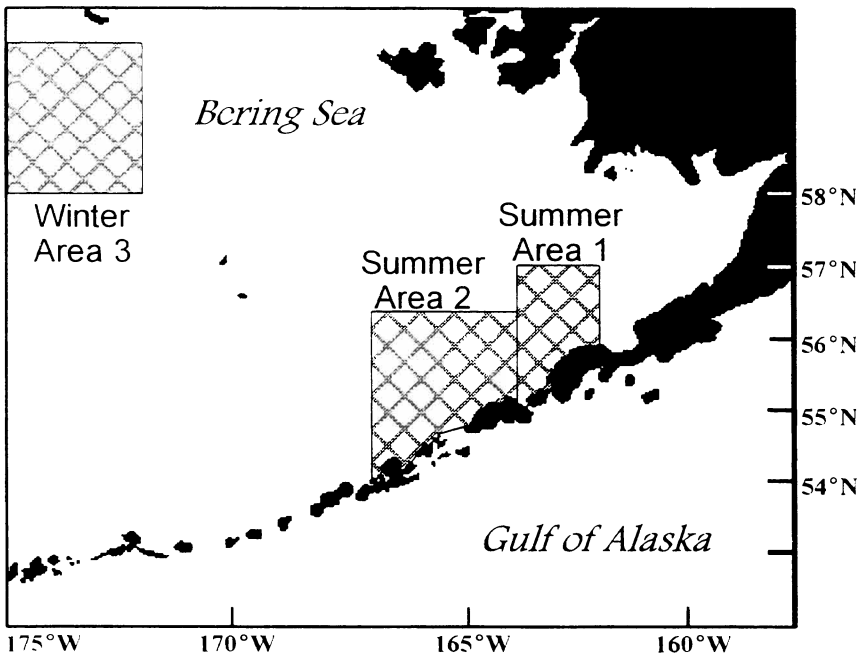

Figure 3. — The three Herring Savings Areas.

Table 2. — Pre-season apportionments of prohibited species for Bering Sea and Aleutian Islands groundfish fisheries, and resulting closures 1996.

Fishery and species	Pacific halibut (mortality in t)	Pacific herring (t)	Red king crab (Zone 1)	Tanner crab (Zone 1)	Tanner crab (Zone 2)	Closure reason 1996
Trawl fisheries						
Yellowfin sole						
Jan 20–Mar 31	160	287	5,000	50,000	1,530,000	Zone 1 Crab 3/20
Apr 1–May 10	150	RO[1]	15,000	200,000	RO	Halibut 6/17
May 11–Aug 14	100	RO	10,000	RO	RO	Halibut 10/26
Aug 15–Dec 31	410	RO	20,000	RO	RO	
Rock sole / other flatfish						
Jan 20–Mar 29	453	NA[2]	110,000	425,000	510,000	Halibut 2/26
Mar 30–Jun 28	139	NA	RO	RO	RO	Halibut 4/13
Jun 29–Dec 31	138	NA	RO	RO	RO	Halibut 6/8, 7/31
Rockfish						
Jan 20–Mar 29	30	7	NA	NA	10,000	
Mar 30–Jun 28	50	RO	NA	NA	RO	
Jun 29–Dec 31	30	RO	NA	NA	RO	
Pacific cod						
Jan 20–Oct 24	1,585	22	10,000	250,000	260,000	Halibut 5/14
Oct 25–Dec 31	100	RO	RO	RO	RO	Halibut 6/23
						Halibut 11/9
Pollock (bottom trawl)/others						
Jan 20–Apr 15	330	154	30,000	75,000	690,000	Halibut 9/7
Apr 16–Dec 31	100	RO	RO	RO	RO	
Pollock (pelagic trawl)	NA	1,227	NA	NA	NA	
Total	3,775	1,697	200,000	1,000,000	3,000,000	
Nontrawl fisheries						
Pacific cod (longline)						
Jan 1–Apr 30	475	NA	NA	NA	NA	Halibut 5/15
May 1–Aug 31	40	NA	NA	NA	NA	Halibut 11/5
Sept 1–Dec 31	285	NA	NA	NA	NA	
Other longline fisheries	100	NA	NA	NA	NA	Halibut 5/15
Groundfish pot fisheries	NA	NA	NA	NA	NA	
Total	900 t					

[1] RO = rollover of remaining allowance until limit is attained.
[2] NA = not applicable.

Analysis of bycatch and "hotspot" areas was greatly enhanced by the implementation of the domestic observer program in 1990, and development of Geographic Information System (GIS) technology. In the early 1990's, GIS technology was used to evaluate proposed trawl closure areas to protect blue king crab, *Paralithodes platypus*, habitat around the Pribilof Islands, and to define hotspot closure areas to control bycatch of chinook and chum salmon, *O. keta*. The Chum Salmon Savings Area (Fig. 4) closes to all trawling during 1–31 August, and remains closed if a bycatch limit of 42,000 chum salmon is taken in the catcher vessel operational area. Trawling is prohibited in the Chinook Salmon Savings Areas (Fig. 4) upon attainment of a bycatch limit of 48,000 chinook salmon in the BSAI. Beginning in 1995, the Pribilof Islands Habitat Conservation Area (Fig. 5) was closed to all trawling on a year-round basis (Fig. 5).

Closure of the Bristol Bay red king crab fishery in 1994 due to poor stock conditions brought about a flurry of regulatory activity to control crab bycatch. A new trawl closure area, called the Red King Crab Savings Area (Fig. 5), was established by emergency rule in 1995, and made permanent under Amendment 37. This 4,000 n.mi.^{2} area in outer Bristol Bay was a prime fishing ground for rock sole and other flatfish, but it was found to have high densities of adult male red king crab. In adopting this area closure, the Council expressed concerns about bycatch and unobserved mortality of these crab. Amendment 37 also prohibited all trawling on a year-round basis in the nearshore waters of Bristol Bay to protect juvenile red king crab and critical rearing habitat that could be impacted by trawling (Fig. 5). This nearshore area encompasses about 19,000 n.mi.^{2}. The third management measure adopted under Amendment 37 was a reduction of existing PSC limits for red king crab taken in trawl fisheries. Based on the 1996 survey abundance index, the 1997 PSC limit was established at 100,000 red king crab in Zone 1.

Two other FMP amendments were adopted in 1996 to manage bycatch of crab. Amendment 41 reduced existing PSC limits for Tanner crab taken in BSAI trawl fisheries. Under this amendment, PSC limits in Zones 1 and 2 are based on total abundance of Tanner crab as indicated by the NMFS trawl survey. Based on 1996 abundance (185 million crabs), the PSC limit was specified at 750,000 crabs in Zone 1 and 2,100,000 crab in Zone 2 for 1997 fisheries. Amendment 40 will establish new PSC limits for *C. opilio*, taken in BSAI trawl fisheries. PSC limits for this species will be based on it's total abundance as indicated by the NMFS standard trawl survey and will be apportioned among trawl fisheries as bycatch allowances. The annual *C. opilio* PSC limit will be set at 0.1133% of its abundance index, with a minimum PSC of 4,500,000 *C. opilio* and a maximum of 13 million. The *C. opilio* taken within the *C. opilio* Bycatch Limitation Zone (Fig. 6) would accrue towards the bycatch allowance specified for individual trawl fisheries. Upon attainment of a *C. opilio* bycatch allowance apportioned to a particular trawl target fishery, that fishery would be prohibited from fishing within the *C. opilio* Bycatch Limitation Zone.

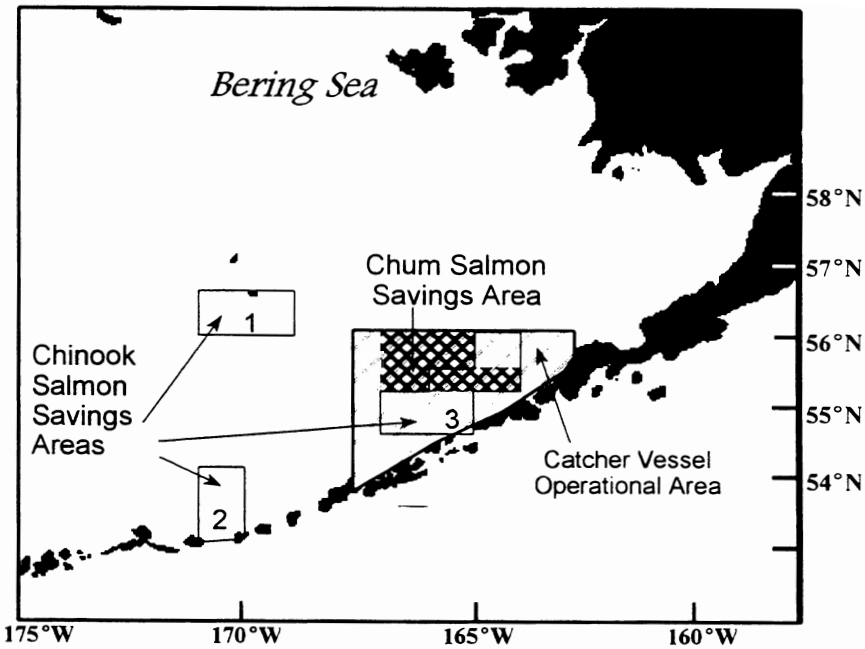

Figure 4. — The Chum Salmon Savings Area, the Chinook Salmon Savings Areas, and the Catcher Vessel Operational Area.

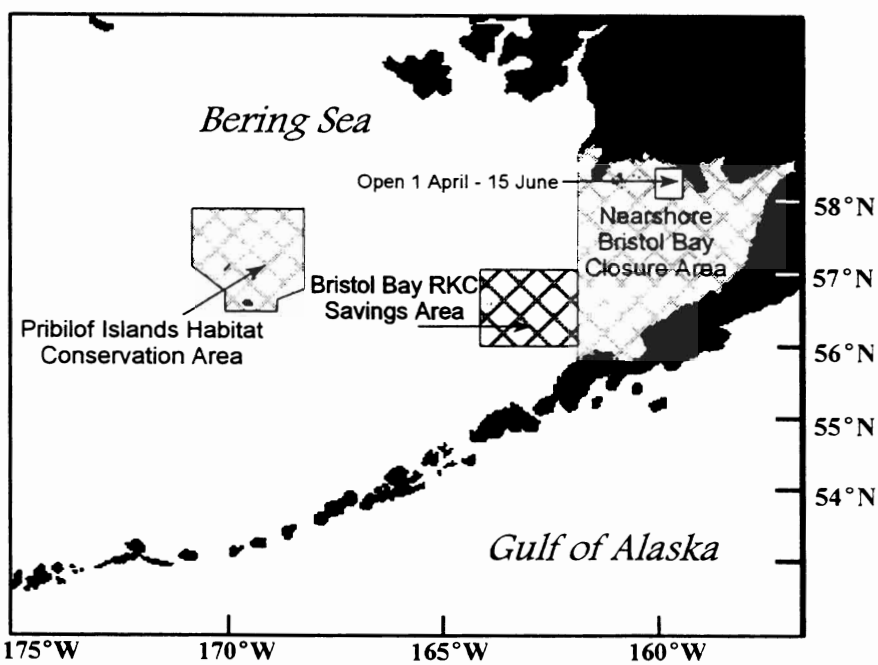

Figure 5. — The Pribilof Islands Habitat Conservation Area, the Red King Crab Savings Area, and the nearshore Bristol Bay trawl closure area.

Discussion

Regulations to control bycatch of certain species have been promulgated primarily to address allocation concerns from competing users of the resource. The bycatch of a prohibited species in the groundfish fishery decreases the amount of those species that can be taken by fishermen in the fisheries for those species, but efforts to decrease bycatch impose costs on groundfish fishermen. Hence, bycatch allocation has been a very contentious issue for the Council process, and will likely continue to be as directed fishery representatives demand more stringent bycatch controls. Unfortunately, optimal allocation of fishery resources among competing users is a problem not easily overcome (Wilson and Weeks, 1996).

One overall goal of the Council has been to maximize groundfish harvests (within biologically acceptable limits) while minimizing bycatch. As such, many regulations have been implemented in the past 20 years to control bycatch and associated mortality of prohibited species in Bering Sea groundfish fisheries. Regulatory measures have included bycatch limits, seasons, gear

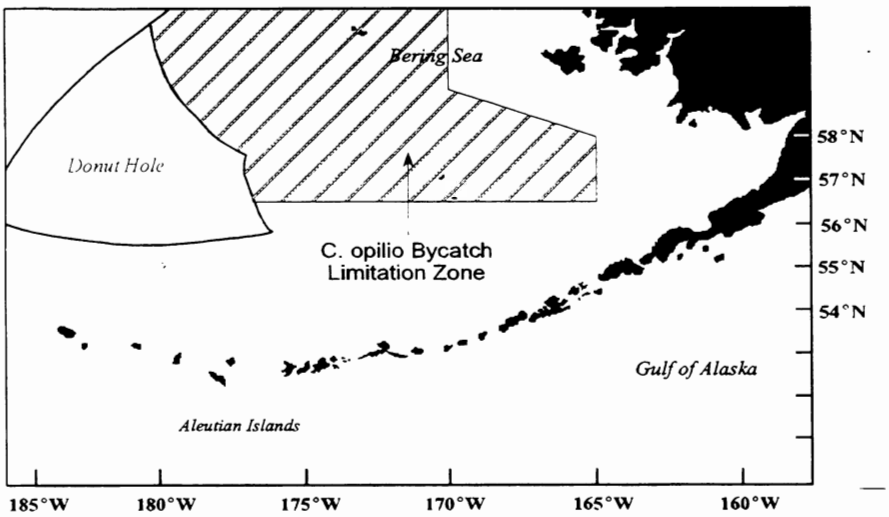

Figure 6. — The *C. opilio* Bycatch Limitation Zone.

Table 3. — Estimated bycatch of Pacific halibut (metric tons of mortality), king crab, Tanner crab, Pacific herring, chinook salmon, and other salmon taken in Bering Sea and Aleutian Islands groundfish fisheries, 1977-96. (1996 data are preliminary).[1]

Year	Pacific halibut (t)	King crab (no., all species)	*Chionoecetes* crab (no., all species)	Pacific herring (t)	Chinook salmon (no.)	Other salmon (no.)
1977	1,758	599,623	17,600,000	NA[2]	47,840	(combined)
1978	3,030	1,227,931	17,300,000	NA	44,548	(combined)
1979	3,269	1,007,796	18,000,000	NA	107,706	(combined)
1980	5,571	1,147,671	11,400,000	783	115,036	6,726
1981	3,866	1,817,152	6,300,000	287	36,218	5,800
1982	2,869	573,919	2,400,000	1,986	15,644	7,686
1983	2,575	1,034,157	3,000,000	2,513	10,334	32,134
1984	2,830	691,088	3,000,000	1,257	11,274	72,195
1985	2,538	1,225,073	2,700,000	4,539	11,069	10,598
1986	3,364	275,066[3]	7,200,000[3]	4,018[3]	9,237	14,433
1987	3,462	147,386[3]	7,400,000[3]	487[3]	22,221	4,799
1988	5,344	88,033[3]	3,100,000[3]	351[3]	30,320	3,709
1989	4,393	207,703[3]	3,800,000[3]	2,527[3]	40,354	5,545
1990	5,176	109,201[4]	1,731,725[5]	3,379	13,990	16,661
1991	6,046	255,607	14,498,270	3,252	35,766	31,987
1992	6,466	315,788	19,613,453	3,758	37,372	38,919
1993	4,684	388,664	18,881,490	1,076	45,964	243,246
1994	5,711	359,436	15,059,028	1,711	43,636	94,508
1995	5,264	48,191[4]	7,695,643	969	23,079	21,780
1996	4,893	28,682[4]	4,730,000	1,510	63,179	77,926

[1] Sources: Guttormsen et al., 1990; Queirolo et al., 1995; NPFMC, 1995; Williams, 1997.
[2] NA = not available.
[3] Foreign and joint-venture bycatch only.
[4] Red king crab only.
[5] *C. bairdi* only.

restrictions, time/area closures, bycatch rate standards, monitoring, and enforcement. Unfortunately, regulations or operational changes designed to reduce bycatch of one species, say Pacific halibut for example, may serve to increase bycatch rates of another PSC species such as Tanner crab. The multispecies nature of bycatch is a dilemma faced by policy makers designing bycatch regulations and fishermen attempting to abide by them.

Beginning in 1982 with the implementation of the BSAI groundfish FMP, regulations and incentives for foreign fisheries worked to control the bycatch of halibut, crab, and salmon (Table 3). Bycatch of these species remained low through 1985, but then increased with development of relatively unconstrained joint-venture operations until 1987 when bycatch limits for these fisheries were established. Bycatch further increased with development of the fully domestic fleet, but was quickly limited by regulation. Bycatch limits for Pacific halibut, Pacific herring, red king crab, and Tanner crab kept the bycatch from reaching higher levels. Bycatch of salmon remained unconstrained through 1994, and bycatch of *C. opilio* remained unconstrained through 1997.

Bycatch of prohibited species has been controlled by bycatch management measures, but not without cost to groundfish fisheries. In particular, halibut bycatch management measures have constrained groundfish harvests. Typically, all bycatch mortality (4,665 t) allocated to trawl and longline fisheries is taken, along with lesser amounts from pot fisheries and fisheries within Alaska state waters (Williams, 1997). Attainment of halibut bycatch mortality limits has caused many closures over the years, and these closures have decreased the amount of groundfish caught. For example, 6 closures were implemented in 1994, 12 closures in 1995, and 14 closures in 1996 due to Pacific halibut bycatch allowances being attained by specific fisheries. A summary of the 1996 closures is shown in Table 2. Pacific halibut bycatch limits have affected bottom trawl fisheries in particular, and consequently, portions of fishing quotas annually specified for most flatfish species have remained unharvested (Witherell, 1995). Longline fisheries have also been constrained by Pacific halibut bycatch, and careful release requirements have been implemented to improve survival of halibut discards (Smith, 1995). However, implementation of an individual fishing quota (IFQ) system for Pacific halibut and sablefish longline fisheries in 1995 allowed for more selective longline fisheries with lower bycatch (Adams, 1995).

Overall crab bycatch has been a function of crab abundance and PSC limits. High bycatches of king crab and *Chionoecetes* crab (mostly *C. opilio*) were taken in the 1970's by foreign fisheries, but regulations and incentives implemented with the FMP in 1982 reduced crab bycatch to much lower levels. In the domestic groundfish fisheries, bycatch of red king crab and Tanner crab have been kept in check with PSC limits for trawl fisheries. Bycatch

of *C. opilio* increased drastically in the early 1990's (Table 3), corresponding to an expanding crab population, so *C. opilio* PSC limits were established in 1996.

Crab bycatch regulations have been based on concerns that trawling impacts crab populations directly in terms of trawl-induced mortality and indirectly through habitat degradation. Observed mortality, as measured by crab bycatch, has accounted for a small percentage of crab populations. For example, bycatch amounted to only 0.5% of the red king crab, 1.2% of the Tanner crab, and 0.1% of the *C. opilio* population on average, for 1992–95 (NPFMC, 1996). Because bycatch is small relative to other sources of mortality, time/area closure are thought to be more effective than PSC limits in reducing impacts of trawling on crab stocks (Witherell and Harrington, 1996). As such, numerous trawl closure areas have been instituted to address concerns about unobserved mortality (crab wounded or killed but not captured), and possible habitat degradation due to trawling and dredging.

The bycatch of Pacific herring and salmon has been controlled by time/area closures triggered by bycatch limits. Pacific herring closures have been effective at maintaining an acceptable level of bycatch in years when herring are abundant on the fishing grounds. This situation occurred in 1992, 1993, 1994, and 1995, when Herring Savings Areas 2 and 3 were closed to trawling for fisheries directed at walleye pollock, *Theragra chalcogramma*; rock sole, *Pleuronectes bilineatus*; yellowfin sole, and other flatfishes. Similarly, salmon bycatch limits are expected to trigger closures only during years when exceptionally high bycatch rates are encountered by the trawl fleet. During the first year of implementation in 1994, the Chum Salmon Savings Area was closed to all trawling from 20 August through 12 November. Without this closure, bycatch may have exceeded the record set in 1993, when over 240,000 chum salmon were taken (Table 3). By far, the highest bycatch rates for chum salmon occur during August, September, and October, with almost no chum salmon taken in other months (NPFMC, 1995).

It should be noted that bycatch of PSC is also controlled by nonregulatory means. Many measures have been embraced by the trawl and longline fleet to control and reduce bycatch of Pacific halibut, crab, and salmon. AGIS application has been used by the BSAI trawl and longline fleet to identify hotspots by using bycatch rates reported by individual vessels (Gauvin et al., 1995; Smoker, 1996). Bycatch rate information from individual vessels is received at a central location, aggregated daily, and then quickly relayed back to the entire fleet in the form of maps, so that hotspot areas can be avoided. PSC rates are reduced and corresponding higher groundfish catches can then be realized by the fleet. Unfortunately, because this is a voluntary program, nonparticipating vessels with high bycatch rates may keep the fleet as a whole from catching the entire quota of flatfish. Some bycatch reduction may also come in the form of peer pressure. Individual vessel bycatch rates are now published on the Internet for all to view. Vessels with high bycatch rates may be shamed into improving their bycatch performance.

Further reductions in bycatch may be achieved with individual vessel incentives. The current system tends to penalize vessels that adopt bycatch reducing tactics because they will probably have reduced catches of target species (Huppert et al., 1992). This external cost is due to the race for fish (and bycatch), as fish are allocated on a first-come-first-served basis. These external costs would be reduced if fishermen paid for the fish they use, or had defined property rights to those resources (NMFS, 1996). Under an individual bycatch quota system, also called a vessel bycatch account (VBA) system, each vessel would have an incentive to reduce its bycatch rate to maximize its catch of groundfish. Vessels with low bycatch rates would benefit by being able to catch additional groundfish without being shut down by vessels with higher bycatch rates, as they are with current fleet-wide bycatch limits. A VBA system could result in more groundfish being caught overall with less overall bycatch of prohibited species. Analysis of a VBA program is underway, and if adopted by the NPFMC and approved, could be implemented in the year 2000.

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