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Bycatch of Kittlitz's murrelet (*Brachyramphus brevirostris*) in commercial salmon gillnet fisheries in the Gulf of Alaska: A qualitative risk assessment

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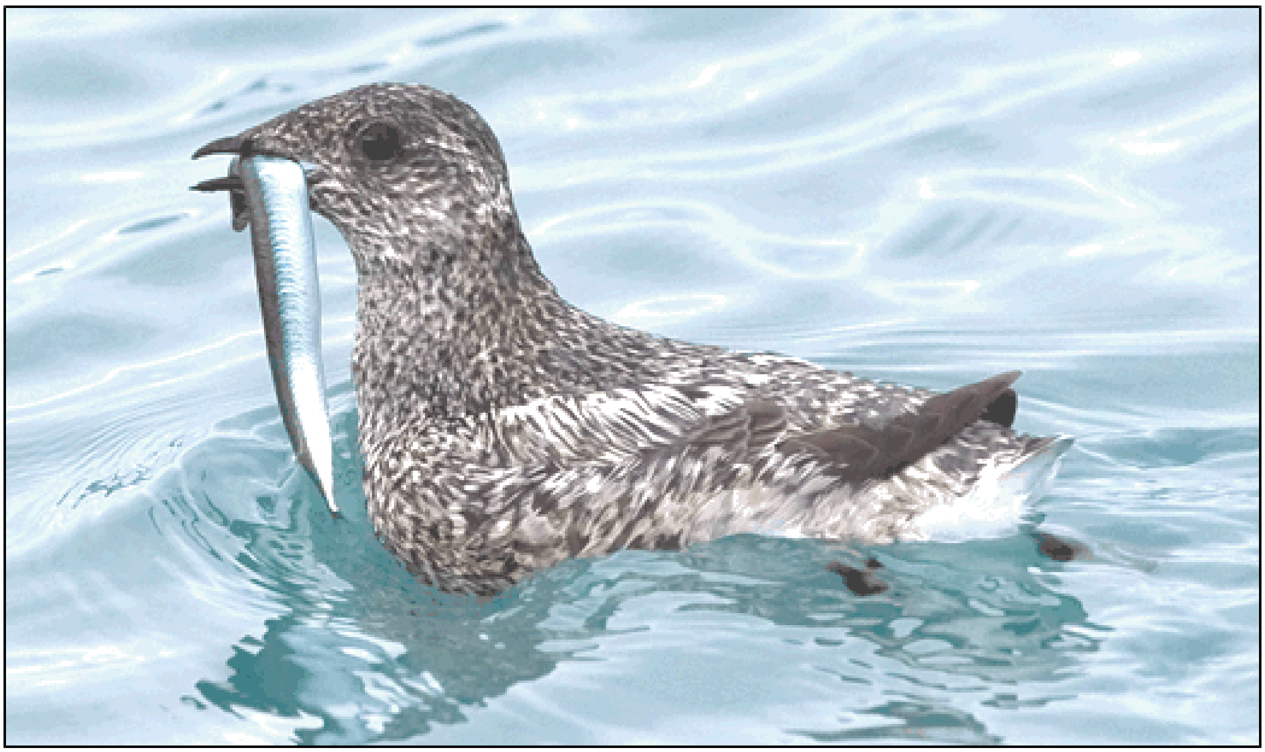

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Alaska Department of Fish and Game Division of Wildlife Conservation

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Cover Photo: A Kittlitz's murrelet holding fish. *National Park Service photo by Mason Reid.*

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Abstract

Bycatch of Kittlitz's murrelets (KIMU) in commercial gillnet fisheries is frequently cited as a conservation concern for this species, but there are few data on KIMU mortality in gillnets. In this study, we assess the qualitative risk of KIMU bycatch in commercial salmon gillnet fisheries by evaluating the spatial and temporal overlap of KIMU and gillnets in 4 study areas where these fisheries have been monitored by the Alaska Marine Mammal Observation Program (AMMOP): Prince William Sound, Cook Inlet, Kodiak, and Yakutat. We used permit-days, the number of gillnet permit holders who reported catching fish on a given day in a given statistical area, as an index of fishing effort. We used existing KIMU survey data to plot KIMU locations relative to fishing effort and identify areas with the greatest potential for fishery interactions. Temporal overlap was high; in all areas except Yakutat both the set and drift gillnet fisheries peaked in late June or July, when Kittlitz's murrelet abundance also peaks. There were localized areas of spatial overlap in all 4 study areas, although in general these were not the areas with the highest fishing effort. Areas at greatest risk for gillnet mortality include Alitak Bay in Kodiak and Manby Shore in Yakutat Bay. KIMU in these areas frequented the lower reaches of the bay, where gillnets also are typically concentrated.

Key words: Kittlitz's murrelet, *Brachyramphus brevirostris*, gillnet, bycatch, mortality, Kodiak, Cook Inlet, Prince William Sound, Yakutat, Gulf of Alaska

Introduction

The Kittlitz's murrelet (KIMU), a small diving seabird, was petitioned for listing under the Endangered Species Act in 2001 due to reported population declines that approached 85% in some parts of its range (Kuletz *et al*. 2003; Kuletz *et al*. 2008; Van Pelt and Piatt 2003; Drew and Piatt 2008). More recent studies suggest population trends in some of those areas may have stabilized (Kirchhoff *et al*. 2010; Kuletz *et al*. 2011b). In response to this and other new information, the Listing Priority Number of this species was reduced in 2010 from 2 (high magnitude, imminent threat) to 8 (moderate or low magnitude, imminent threat; USFWS 2011). Shortly after the downlisting, a report commissioned by the Alaska Department of Fish & Game (ADF&G) concluded that substantive differences in methods among study sites and years precluded using earlier surveys as baselines for trend estimation and questioned the magnitude of the initial declines (Day 2011). Debates over the population trend and status of this species continue, and the USFWS recently initiated a listing evaluation under the Endangered Species Act. The listing evaluation must be completed and published in the Federal Register by 30 September 2013 (Kissling, letter to Pacific Seabird Group Executive Committee).

One important component of the listing evaluation will be to assess the magnitude and immediacy of the potential threats to this species. In the 2011 Candidate Notice of Review (CNOR), the threat level was designated as moderate. Although low reproductive success was identified as the greatest concern, the CNOR also noted that "For a K-selected species such as Kittlitz's murrelet, loss of the adults is particularly important and we have identified several sources of adult mortality such as hydrocarbon contamination, entanglement in gillnets, and predation…We consider the magnitude of threat from these sources to be low to moderate, depending on events that occur in a given year (number and location of oil spills/ship wrecks, number and location of gillnets)" (USFWS 2011). The CNOR also concluded that "Threats to Kittlitz's murrelet adults are ongoing and include hydrocarbon contamination and bycatch in commercial fisheries. In addition, several lines of evidence point to poor reproductive effort and success with no lines of evidence to the contrary. Consequently, we conclude that the combined threats to the species are imminent." (USFWS 2011). As 1 of only 2 threats cited in both the Magnitude and Imminence justification sections in the 2011 CNOR, it is critical to examine more closely the potential risk that gillnet fisheries pose to Kittlitz's murrelets in Alaska.

Diving seabirds are particularly susceptible to entanglement in gillnets (Žydelis *et al*. 2009) and bycatch in salmon gillnet fisheries has long been recognized as an important source of mortality for the marbled murrelet (Carter and Sealy 1984, Carter *et al*. 1995, DeGange *et al*. 1993), a species closely related to KIMU. Bycatch also has been listed as a conservation concern in almost every document related to the conservation or status of Kittlitz's murrelets in Alaska (BirdLife International 2012, Center for Biological Diversity 2009, USFWS 2011). However, there are very few data on KIMU mortality in gillnets. The rationale for including bycatch as a conservation concern for KIMU appears to be based largely on the documented threats to marbled murrelets (MAMU).

The only data relating specifically to bycatch of KIMU in gillnets come from the Alaska Marine Mammal Observation Program (AMMOP). The Marine Mammal Protection Act (1972) required observer programs to categorize fisheries according to incidental take of marine mammals. In

Alaska, seabird bycatch also has been monitored as part of the AMMOP. There have been 4 observer programs focused on salmon gillnet fisheries in Alaska: Prince William Sound/Copper River Delta (1990–91), Cook Inlet (1999–2000), Kodiak (2002, 2005), and Yakutat (2007–08). Kittlitz's murrelets were caught in 3 out of 4 of these observer programs, but the number of birds killed was small (9 in Prince William Sound/Copper River Delta, 1 in Kodiak, 1 in Yakutat, and 0 in Cook Inlet). Unfortunately, the raw data from Prince William Sound (PWS), where 82% of the documented Kittlitz's murrelet bycatch occurred, are no longer available (B. Mansfield, NMFS, Juneau, personal communication). The reports from that program did not include any specifics about the Kittlitz's murrelet mortalities (date, time, location, etc.), precluding any assessment of factors contributing to entanglement and mortality for this species. Small sample sizes, problems with and changes in sampling design and methods among programs, and limited observer coverage also preclude estimating meaningful bycatch rates for this species using observer program data (Wynne 1992; Manly 2006; Manly 2007).

Greater numbers of marbled murrelets relative to Kittlitz's murrelets were caught in all 4 AMMOP areas (48 in PWS, 1 in Cook Inlet, 10 in Kodiak, and 16 in Yakutat), raising the possibility of using this species as a proxy for assessing the risk posed by commercial gillnet fisheries to Kittlitz's murrelets. Given the similarities in their foraging behavior (Day and Nigro 2000), it seems reasonable to assume the probability of entanglement upon encountering a gillnet would be similar for the 2 species. However, there are substantial differences in the spatial distribution and habitat associations of Kittlitz's and marbled murrelets that could result in the 2 species having very different probabilities of encountering a net. In this study, we use data on KIMU distribution and gillnet fishing effort to identify areas of overlap between KIMU and gillnets and to qualitatively assess the relative risk of gillnet mortality in those areas based on intensity of fishing effort and KIMU abundance.

Methods

GILLNET FISHERIES

Salmon gillnet fisheries are limited-entry, nearshore fisheries managed by the Alaska Department of Fish & Game. Salmon management areas are divided into fishing districts and districts are further divided into subdistricts and statistical reporting areas. The statistical reporting area (statistical area) is the finest scale at which ADF&G records information on commercial harvests. This study analyzes effort in commercial gillnet fisheries in the 6 salmon management areas that have been observed by the AMMOP: Prince William Sound, Copper River, Upper Cook Inlet, Lower Cook Inlet, Kodiak, and Yakutat (Fig. 1).

Gillnets consist of a multifilament web with a float line at the top of the net and a weighted lead line on the bottom. The nets are generally set perpendicular to the direction the salmon are traveling and snare the fish by the head and gills. There are 2 types of gillnet fisheries in Alaska: drift gillnets and set gillnets. Drift gillnets are typically 150 fathoms long and attached to the vessel on one end, with the other end floating free. At the end of the soak, the net is hauled in with a hydraulic drum and picked by hand. Set gillnets are anchored on both ends, usually with one end on shore, although nets also can be set in shallow waters offshore. The nets are picked by hand in sections, effectively allowing them to fish continuously. The size of the mesh openings, length and depth of the net, and number of nets that may be operated by a permit holder vary among and within management areas. For both gear types, fishing periods are typically opened and closed by emergency order and the duration and timing of openings varies by area and also from year-to-year.

STUDY AREAS

Kodiak

The Kodiak Management is divided into 6 fishing districts around Kodiak and Afognak Islands and there are set gillnet fisheries in 2 of those districts, Northwest Kodiak and Alitak Bay (Fig. 2). Within the Alitak Bay district, the inside waters are open for set gillnets and the outer waters are open to seine gear. The Central Section of the Northwest District is open to both set gillnets and seine gear. The AMMOP observed gillnet fisheries in Kodiak in 2002 and 2005.

Cook Inlet

Cook Inlet is divided into 2 management areas: Upper Cook Inlet and Lower Cook Inlet. The Upper Cook Inlet salmon management area is divided into 2 districts: Northern and Central. There are set gillnet fisheries only in the Northern District and both drift and set gillnet fisheries in the Central District (Fig. 3). Of the 5 districts in the Lower Cook Inlet management area, only the Southern District includes areas where set gillnet fishing is allowed, with the remaining 4 districts restricted to purse seine gear only (Fig. 3). In this report we refer to the Northern, Central, and Southern districts collectively as the Cook Inlet management area.

The Central District drift and set gillnet fisheries are the primary fisheries in Cook Inlet. The drift gillnet fishery generally occurs only during daylight hours (Manly 2006). In the Southern District, set gillnetting is confined to 5 commercial set gillnet zones within the larger statistical areas, all along the south shore of Kachemak Bay (Fig. 4). These zones are delineated by landmarks on shore and extend out 1,000 to 2,500 ft. from the shoreline. Gillnet permit holders can obtain a lease from the Department of Natural Resources (DNR) giving them priority fishing rights for a specific section of the open areas. There are only enough productive fishing sites within the gillnet zones to accommodate 25 set gillnets (Hammarstrom and Ford 2011). The AMMOP observed gillnet fisheries in Cook Inlet in 1999 and 2000.

Prince William Sound

Although Prince William Sound and the Copper River Delta are managed as separate areas by ADF&G, in this report we group them together as the Prince William Sound management area. This area is divided into 11 fishing districts, 6 of which allow gillnetting in all or part of the district: 4 of those districts are located within Prince William Sound and the other 2 are in the Copper River Delta. All gillnet fisheries in this region are driftnet fisheries with the exception of the Eshamy District, which has both a drift and set gillnet fishery (Fig. 5). During the period considered here (2000–2010), the Montague District was open only for the 2009 and 2010 seasons. The AMMOP observed gillnet fisheries in Prince William Sound in 1990 and 1991.

Yakutat

The Yakutat Management Area is divided into 2 fishing districts, Yakutat and Yakataga, and set gillnets are allowed in the inner waters of both of these districts (Fig. 6). This area is unique in that the outer coast waters are closed to gillnet fishing except those areas immediately adjacent to the river and stream mouths (Woods and Zeiser 2011). Most gillnet activity therefore occurs within the major river and stream systems and their estuaries, with limited activity in adjacent ocean areas (Fig. 7). There also are 2 ocean fisheries (Manby Shore and Yakutat Bay) that occur within Yakutat Bay (Woods and Zeiser 2011). Gillnet fishing is prohibited in Icy Bay, the only other large bay in this management area (Fig. 7). The AMMOP observed gillnet fisheries in Yakutat in 2007–08.

FISHING EFFORT

Commercial gillnet fisheries are managed as limited-entry fisheries in Alaska and a permit is required to participate. Each permit holder is required to complete a "fish ticket" upon delivery of fish to a port or processor. The name, permit number, the date the fish were caught, and the statistical area where the fish were taken are reported on the fish ticket. We used permit-days, defined as the number of permit holders that reported catching fish on a given day in a given statistical area, as an index of fishing effort. In 2008, regulations were amended in the Kodiak Management Area to allow set gillnet permit holders to own and operate 2 permits at once. Due to inconsistencies in reporting procedures for dual permit holders, fishing effort for the 2008–2010 seasons in Kodiak was underestimated (Jackson *et al.* 2010). Data were obtained by querying the ADF&G Salmon Fish Ticket Database for the period 2000–2010.

To examine spatial distribution of fishing effort, we calculated the average annual number of permit-days for each statistical area for the period 2000–2010 and compared fishing effort within and among areas. Because openings generally occur on specific days of the week (e.g., Tuesdays) rather than specific dates (e.g., 1 June), for temporal comparisons of fishing effort we calculated average permit-days by statistical week. We were primarily interested in the magnitude of effort when an area was actively being fished, therefore we did not include weeks with zero effort when calculating averages. ADF&G statistical weeks are 7 days long and run from Sunday through Saturday. The first statistical week of any given year ends on the first Saturday in January and may be less than 7 days long. Subsequent weeks are numbered chronologically through the end of the year. To facilitate comparison with bird survey data, we grouped the statistical weeks into “months” (Table 1), recognizing that the first and last statistical week in each “month” might fall into a different calendar month during some years.

GILLNET DISTRIBUTION AND BYCATCH

Statistical areas are larger than the areas that are actually fished, therefore we also examined the distribution of gillnets within each of the 4 study areas. For Cook Inlet, Kodiak, and Yakutat we used locations of gillnets sampled during the AMMOP to determine the area fished. Sampling methods and coverage varied among both programs and years. The method used to sample permits in Cook Inlet was not specified, but coverage of both set and drift gillnet fisheries was low and uneven, ranging from < 0.35% of estimated fishing effort in the Southern District set gillnet fishery during both years to 3.6% in the drift gillnet fishery in 2000 (Manly 2006). In Kodiak, the Alitak Bay District was closed to fishing in 2002. Permits were randomly sampled for the entire Northwest District and estimated coverage was 6% of fishing days. In 2005, permits were randomly sampled separately for each of 7 bay systems. Coverage was estimated at 4.9% of fishing days in 2005 (Manly 2007). In Yakutat, the area was divided into 4 fishery regions: the Alsek River, the Situk-Ahrnklin Rivers, the Yakataga District, and Yakutat Bay and the remaining outer coast drainages. Sampling methods changed over the course of the program: permits were initially sampled separately for the 4 regions, but in 2008 all permits were randomly sampled for the entire area. Coverage was > 5% for all regions except for the Alsek River in 2007 (Manly 2009).

We also conducted aerial surveys of gillnets in Yakutat and Prince William Sound in 2009 and 2010. Gillnet cork lines and buoys are clearly visible from the air (Fig. 8), therefore we flew fixed-wing aircraft along the shoreline and recorded a GPS location at each set gillnet, noting whether the net was attached to land or located offshore. Although drift gillnets are supposed to drift freely, in PWS we often observed the floats on the free end resting on the shore at low tide, resulting in the drift gillnets being distributed along the shore similarly to set gillnets (Fig. 8). We therefore followed the same procedure for drift gillnets in PWS in all areas except the Eshamy District, where most of the drift boats were fishing offshore. Because the boats were scattered, it was difficult to accurately record the position of each net from the plane. Therefore we divided the shoreline into sections, flew along the outer edge of the area the boats were fishing, and counted the number of driftnets within each section. We surveyed the Yakutat District 4 times in 2009–10 from Yakutat Bay south; 3 of those surveys were conducted in conjunction with boat-based murrelet surveys. We surveyed 3 gillnet fishing districts in Prince William Sound proper once in 2009. We did not survey the Copper River Delta, because murrelet survey data were not available for those areas.

Locations of marbled and Kittlitz's murrelet bycatch were obtained from the AMMOP database for all areas except Prince William Sound. The raw data from the Prince William Sound observer program are not available (B. Mansfield, NMFS, personal communication) and the reports do not give details about the location or date of the mortalities or the disposition of the carcasses. We deduced from museum records that 4 Kittlitz's and 15 marbled murrelet carcasses from the PWS AMMOP were deposited at the Burke Museum and obtained locations for those birds from the specimen records.

KIMU DISTRIBUTION

We compiled earlier murrelet survey data from USFWS, USGS, and others to determine KIMU distribution in each of the study areas (Table 2). We used data from multiple surveys when available to qualitatively assess how stable the distribution of KIMU was across seasons and years. Because survey coverage, dates, and methods were rarely comparable across years in any given study area, a quantitative analysis was not possible.

Kodiak

There have been numerous marine surveys of the Kodiak archipelago dating back to the 1980s (Stenhouse *et al*. 2008). Although none of these surveys specifically targeted murrelets, because at-sea sightings are so rare, observations of Kittlitz's murrelets (on or off transect), were always recorded (D. Zwiefelhofer, personal communication; R. Corcoran, USFWS, personal communication). We included all summer (May to August) observations from systematic surveys during 1991 to 2005 as reported in Stenhouse *et al*. (2008). Survey details, including dates, purpose, coverage area, and transect type were available only for the harlequin duck and nearshore marine bird surveys.

The only systematic surveys that were repeated in multiple years were shoreline surveys for harlequin ducks. These were conducted during 1994 to 2010 on northwestern and southeastern Kodiak Island and a small section of western Afognak Island (Zwiefelhofer 1997, 2000, 2003, 2007; Fig. 9). The west side (Kodiak and Afognak) surveys were originally conducted in May and August of each year from 1994 to 1997 and covered most of the shoreline in Uyak and Uganik bays and the southern half of Viekoda Bay (Zwiefelhofer 1997). The surveys were repeated in August from 2004 to 2007, although they covered a smaller area that included a few of the lower and most of the upper reaches of Uyak Bay and the lower reaches of Uganik Bay (Zwiefelhofer 2007). The western coastline of the Kodiak NWR on Kodiak Island was surveyed a final time in 2009 and the Afognak portion in 2010 (R. Corcoran, UWFWS, personal communication). The shoreline of Alitak Bay was surveyed in May and August from 2001 to 2003 (Zwiefelhofer 2003); in addition, pelagic surveys were conducted there in 1993 (D. Zwiefelhofer, personal communication). Southeastern Kodiak and Sitkalidak Island were surveyed in May and August from 1998 to 2000 (Zwiefelhofer 2000).

In 2011, the Kodiak NWR established systematic nearshore transects from randomized starting points covering roughly 20% of the coastline of the Kodiak Archipelago. Approximately 1/3 of the area is to be surveyed in both June and August each year. The first surveys in 2011 covered the eastern side of Kodiak Island (including Alitak Bay) and the 2012 surveys covered Afognak and Shuyak Islands (Fig. 9); the west side of Kodiak will be surveyed in 2013 (R. Corcoran, USFWS, personal communication).

Cook Inlet

The most extensive marine bird and mammal survey of Cook Inlet was conducted in June 1993, and covered the southern half of Cook Inlet, including the Central District south of Kalgin Island and all of the gillnet areas in the Southern District (Agler *et al*. 1998; Fig. 10). Although this survey had the best coverage of the most intensively fished areas, most (81%) of the murrelets sighted were not identified to species (Agler *et al*. 1998). This was followed by a series of 4 surveys of lower Cook Inlet in the late 1990s that focused on the Southern District and the southwestern portion of the Central District (Kuletz *et al*. 2011a; Fig. 10). There were 3 additional July surveys during 2005 to 2007 that systematically covered the offshore waters of Kachemak Bay (Kuletz *et al*. 2011a; Fig. 11).

The 1993 survey provided good coverage of the most intensively fished areas in the Central District south of Kalgin Island, but coverage of those areas in subsequent surveys was limited

(Fig. 10). Coverage of set gillnet statistical areas in the Southern District varied by survey. The 1993 survey had the best coverage of the larger statistical areas, although the 1997–99 surveys had the greatest overlap with the commercial set gillnet zones (Fig. 11).

Prince William Sound

PWS-wide surveys for all marine birds were conducted by USFWS in July 2005, 2007, and 2010. These surveys had 2 strata: shoreline (<200 m from shore) and offshore (all remaining waters; Kuletz *et al*. 2011b). Coverage was good for 3 out of 4 gillnet fishing districts in PWS, but the Unakwik District contained only part of a single shoreline transect in the extreme southeast corner of the district (Fig. 12). Intensive surveys conducted in 2001 and 2009 by the USFWS specifically targeted Kittlitz's murrelet habitat within PWS (Kuletz *et al*. 2011b). These surveys expanded coverage of bays and fjords included in the PWS-wide surveys and added additional areas, including Unakwik Inlet. Coverage was good for the Unakwik District and 2 statistical areas in the Coghill District, but no transects fell within the Eshamy or Montague Districts (Fig. 12). No survey information was available for the Copper River Delta area.

Yakutat

Most survey effort in the Yakutat area has been focused on Icy Bay (Kissling *et al*. 2011), where gillnet fishing is not allowed. Stephensen and Andres (2001) conducted pelagic and shoreline surveys of Yakutat Bay, but they recorded the total numbers of each species observed on each transect rather than locations of individual birds. A pelagic survey of Yakutat Bay and Russell Fjord was conducted by USFWS in June 2009 (Kissling et al. 2011; Fig. 13), but these pelagic transects did not extend to shoreline areas where gillnetting occurs. We therefore conducted 2 nearshore surveys for murrelets in June and July of 2010 for this study. The surveys covered lower Yakutat Bay and the outer coast south to Dangerous Bay (Fig. 13): gillnetting does not occur in upper Yakutat Bay due to icebergs. We divided lower Yakutat Bay into 4 pelagic transects that crossed the bay at the mouth and again just above Knight Island and 8 nearshore transects that covered the western shoreline (Manby Shore) and inner islands (Fig. 13). Because set gillnets were either anchored to the beach or set in a shallow area close to shore, we oriented the nearshore transects parallel to the shore at a distance of approximately 200 m—the actual distance varied in some areas depending on tides and surf conditions. The 2 outbound transects along the outer coast also paralleled the shore at a distance of 200 m; the 2 return transects were located approximately 600 m from shore. These distances also varied in areas where we were forced to detour around shifting shallows near river mouths.

We surveyed murrelets from a 30-foot charter fishing vessel traveling at 8–10 knots. Two observers sat on the roof of the vessel at an eye height of 3 m above the water and used 8x40 binoculars to survey the waters within 200 m of the center line. One observer was responsible for sighting along the centerline and the waters to the port side, while the other observer sighted on the starboard side of the vessel. Sightings were verbally relayed to a third person, who sat in the bow of the boat facing the observers and recorded the data, along with a GPS location for each sighting. Although number and species of murrelets were the focus of the survey, other birds and mammals were recorded when time permitted. The location of gillnets also were recorded.

SPATIAL AND TEMPORAL OVERLAP

We examined spatial overlap of KIMU and gillnet fishing at 2 spatial scales. At a coarse scale, we plotted KIMU survey locations relative to fishing effort within each statistical area to identify areas with the greatest potential for fishery interactions. At a fine scale, we plotted KIMU survey locations relative to locations of individual gillnets within those statistical areas. We also examined the seasonal pattern of fishing effort relative to what is known about seasonal patterns in KIMU presence for each area.

In our assessment of overlap, we relied on data from disparate data sets that were collected independently of each other and did not always cover the same time periods. In Prince William Sound and Yakutat, all of the Kittlitz's murrelet surveys included in this assessment were conducted during the same 11-year period used to estimate fishing effort (2000-2010). However, in Cook Inlet the surveys conducted in the 2000s were limited to Kachemak Bay—all of the area-wide surveys occurred in the 1990s, prior to the period for which fishing effort was estimated. In Kodiak, there were several surveys of gillnet areas during 2000-2010, however we also included survey data from the 1990s and 2011. In none of the 4 study areas were data on gillnet and Kittlitz's murrelet locations collected simultaneously. Our approach of identifying overlap areas rests on the assumption that the distributions of both gillnets and Kittlitz's murrelets in each of the study areas are relatively stable within and across years. If this assumption is valid, using data from different years to identify overlap areas is reasonable. If this assumption does not hold however, then both overlap areas and bycatch risk would change from one year to the next and this approach cannot be used to assess relative risk of bycatch in a given area.

Results

FISHING EFFORT

All gillnet fishing in the management areas covered by this report occurred during statistical weeks 18 through 45 (late April or early May through the first or second week in November). Almost half (49.8%) of the total annual gillnet fishing effort in the 4 study areas occurred in PWS, 27.8% in Cook Inlet, 13.2% in Kodiak and 9.3% in Yakutat (Fig. 14).

Drift gillnetting occurred only in the PWS and Cook Inlet study areas and composed 54% of the total gillnet fishing effort during the years 2000–2010. The drift gillnet fishery dominated in PWS, whereas effort was split nearly equally between the gear types in Cook Inlet (Fig. 14). In PWS, the drift gillnet fishing season lasted from mid-May through late September or the first week in October (weeks 20–40; Fig. 15). Effort was bimodally distributed, with high and steadily increasing effort during the first half of the season, a strong peak in early July (week 27) followed by a rapid decline, and a much smaller peak in early September (week 36; Fig. 15). The drift gillnet season was much shorter in Cook Inlet, lasting from late June through the beginning of September (weeks 25–36), with a strong peak in July (weeks 29–30; Fig. 15).

Most effort for the set gillnet fishery occurred between the end of May and the last week of September (statistical weeks 22–39), during which period there was some effort in all 4 management areas (Fig. 16). In PWS, the set gillnet fishery typically opened 2 weeks earlier than in the other management areas and in Yakutat there was some effort as late as early November. Effort in PWS peaked early in the season, in late June (week 26); it peaked approximately 3 weeks later (week 29) in Cook Inlet. Kodiak and Yakutat both showed a bimodal pattern of effort. Kodiak peaked first in late June (week 26), followed by a larger peak in late July (week 31). Yakutat peaked first in mid-July (week 29), followed by a larger peak in late September (week 38), when the season was ending in the other management areas (Fig. 16).

Kodiak

Fishing effort

Alitak Bay had the highest level of effort in the Kodiak management area, followed by the major bay systems (from south to north) on the western side of the island (Fig. 17). Effort was lowest on the northern end of the island, in Kupreanof Strait and Kizhuyak Bay (Fig. 18). Effort was uniformly high in the Alitak Bay district and uniformly low in Kizhuyak Bay, whereas on the western side of the island, effort was high in the main bodies of the bay systems and low in the arms (Fig. 18).

All 6 bay systems show a similar seasonal pattern in fishing effort, with relatively uniform effort during weeks 24–34 (mid-June to late August) except for a slight dip in effort during weeks 28–30 (mid-July; Fig. 19). During most weeks, Alitak Bay had the highest effort, although effort was more variable there than in the other bay systems (Fig. 19). Despite the dip in effort in the middle of the month, effort peaked in July in all statistical areas except for the western half of Uganik Bay, where effort peaked the following month, in August (Fig. 20). Although the magnitude of effort in each statistical area changed from month to month, relative effort among statistical areas changed very little over time and closely mirrored the distribution of annual effort (Figs. 18, 20). The one exception was Uganik Bay, where effort shifted from the eastern half to the western half of the bay as the season progressed (Fig. 20).

KIMU distribution

A total of 46 KIMU were observed on all systematic summer surveys combined during 1991–2012. There were 7 KIMU sighted on 4 out of 26 harlequin duck surveys; 2 on Afognak and 5 in the western bays on Kodiak Island. All 5 Kodiak birds were observed in the upper arms of the bays (Fig. 21). Other summer surveys in 1991, 1993, 1997, and 2002 found a total of 7 birds in this area: 5 in the upper arms of Uyak, Uganik, and Viekoda bays, and 2 in the lower reaches of Uganik and Uyak Bays (Fig. 21). No KIMU were observed during shoreline or pelagic surveys of Alitak Bay, but during the 2011 nearshore survey, 3 adults and 1 hatch year bird were observed in gillnet areas in Alitak Bay and 8 other adults were observed elsewhere in the bay, although most were off-transect (R. Corcoran, USFWS, unpublished data; Fig. 21). Other summer surveys in 1993, 1998, 2001, 2005, and 2009 observed a total of 13 birds on the east side of the island (Fig. 21). There were 8 observations were of multiple birds; 6 of these observations occurred in June.

Gillnet distribution, overlap and bycatch

Gillnets were well distributed in statistical areas where fishing effort averaged >300 permit days annually and the distribution was similar among months and years (Fig. 20). On the west side of the island, few or no nets were sampled in the upper reaches of the bay systems where most of the Kittlitz's murrelets were observed (Fig. 22). One adult KIMU was observed in June near the shoreline of Alitak Bay in an area where gillnets were sampled in both June and July; a hatch year bird was observed nearby in August (Fig. 22). The only Kittlitz's murrelet caught as bycatch was killed in Alitak Bay near the border of the Moser Bay Section in mid-July; gillnets were sampled by the AMMOP in this area during all 3 months (Figs. 20, 22).

Cook Inlet

Fishing effort

Fishing effort for both the drift and set gillnet fisheries in the Central District was an order of magnitude higher than in the Northern and Southern districts (Fig. 23). Within the Central district, most of the effort was concentrated along the eastern shore of Cook Inlet, in the Central East drift area, the Drift Corridor, and adjacent set gillnet areas. Effort was low in Chinitna Bay, along the eastern shore of Kalgin Island, and along the western shore of the inlet, and moderate elsewhere in the district (Fig. 24). Most of the effort for both the drift gillnet (91%) and set gillnet (88%) fisheries in the Central District was concentrated in a 6-week period in the middle of the season, from mid-June through early August (stat weeks 27–32; Fig. 25).

Effort in the Northern District was more than twice that in the Southern District (Fig. 23). In only 1 statistical area did the average effort exceed 100 permit-days per year; in the Southern District only1 area exceeded 50 permit-days per year (Fig. 24). In contrast to the Central District, effort was more evenly distributed across the season in both the Northern and Southern Districts (Fig. 25). Effort in the Southern District peaked at 31.5 permit days per week in mid-July (week 28); by early to mid-August (week 33) it averaged less than 5 permit-days per week (Fig. 25).

Fishing effort peaked in July or remained stable across months in all statistical areas and ceased altogether in most areas in the Central and Southern districts by September (Figs. 26, 27). Similarly to Kodiak, relative effort among statistical areas changed very little over time.

KIMU distribution

The 2 largest and most consistent aggregations of KIMU were in upper Kachemak Bay and the offshore waters between Anchor Point and Homer; both areas are closed to gillnetting (Fig. 28). Aggregations of KIMU also were found in multiple years northwest of Anchor Point, within the SE Drift statistical area, and a smaller number of birds were observed regularly off the southern tip of the Kenai Peninsula, which is closed to gillnets (Fig. 28). There were few or no KIMU in the western half of Cook Inlet and Kamishak Bay during all years (Fig. 28).

Nineteen out of 73 KIMU (26%) sighted on the 1993 survey were observed in drift gillnet areas in the Central District (Fig. 29). No KIMU were observed in the Central East section, the Drift Corridor, or the adjacent set gillnet areas, which had the highest levels of fishing effort (Fig. 29), although 4 MAMU and 17 unidentified murrelets were observed here. Similar numbers of KIMU were observed in drift gillnet areas in 1996 (21 birds) and 1998 (22 birds), but only 2 birds were observed in these same areas in 1997 and 4 birds in 1999 (Fig. 29). Most birds in the 1996–1999 surveys were located in the eastern half of the inlet (Fig. 29).

There were 20 KIMU observed in or immediately adjacent to gillnet statistical areas in the Southern District during all 8 surveys combined (Fig. 30). At least 1 KIMU (9 total) was observed along the eastern shore of the Halibut Cove subdistrict during most years, 4 KIMU were observed in Tutka Bay and 2 in Seldovia Bay in 1993, and 1 KIMU was observed in Tutka Bay and 3 others were observed in or adjacent to the Barbara Creek Subdistrict during the 1997–99 surveys (Fig. 30).

Gillnet distribution, overlap and bycatch

In the southern third of the Central District, nets were concentrated down the center of Cook Inlet during both years of the AMMOP. Most KIMU observed in the southern third of the Central District were found either east or west of the main concentration of nets, although there were some birds (particularly on the 1996 survey) in areas where gillnets also were sampled (Fig. 29). The area of greatest overlap between KIMU and nets was in the SE Drift section, along the eastern edge of the high net density area; there also were several observations of KIMU in the western half of the inlet near net locations (Fig. 29). In the Southern District, 2 KIMU were observed within the commercial set gillnet zones in 1999; 1 in Port Graham and 1 in Tutka Bay (Fig. 30). There was no KIMU bycatch observed during the Cook Inlet AMMOP.

Prince William Sound

Fishing effort

The Copper River District had the highest gillnet fishing effort in the Prince William Sound Management Area, exceeding the combined effort in the Coghill and Eshamy Districts, the 2 districts with the highest effort within Prince William Sound proper. Effort was moderate in the Montague District when that area was open, which occurred only twice, in 2009 and 2010. Effort was low in the Bering River District and minimal in the Unakwik District (Fig. 31). Effort was relatively uniform throughout the Copper River, Bering River, and Eshamy districts, but was concentrated around Esther Island (particularly south of the island) in the Coghill District (Fig. 32).

Fishing effort in the Copper River District peaked in late May to early June (weeks 21–23), which was early relative to the other districts (Fig. 33). The Coghill District peaked in week 25 (late June), while the Eshamy and Montague Districts peaked a week or two after that. Most of the effort in the Bering River District occurred late in the season, in September weeks (36–38; Fig. 33). In the Copper River District, effort was greatest in the outer waters south and east of the barrier islands early in the season and shifted to the western end of the district and inside waters later in the season (Fig. 34). In the Coghill District, effort was moderate to high during all months in the area south of Esther Island, but dropped to low levels by August in most of the rest of the district (Fig. 34).

KIMU distribution

On the PWS-wide surveys, most KIMU were associated with fjord or bay systems in northern and western PWS, although small numbers were scattered across the interior of the sound in every year (Fig. 35). The largest and most consistent aggregations were in the heads of College and Harriman Fjords in the Coghill District. Other hotspots included Columbia, Blackstone, and Icy Bays; these areas are all closed to gillnet fishing (Fig. 35). The intensive surveys found aggregations of KIMU in most of these same areas, as well as in Unakwik Inlet. Half of all KIMU recorded on the 2 intensive surveys were observed in the Coghill and Unakwik districts, indicating substantial coarse-scale overlap between KIMU and gillnet fishing in that part of PWS (Fig. 35).

Gillnet distribution, overlap and bycatch

We conducted an aerial survey of gillnets in Prince William Sound on 29 June 2009. Most of the 254 gillnets observed during that survey were located in the Eshamy District (77%), around Esther Island (13%), or in the Montague District (7%), areas where KIMU were not observed (Table 4, Fig. 36). There were 7 gillnets located along the eastern side of College Fjord; all were located south of Coghill Lake, >7 km south of the closest KIMU observation (Fig. 36). The Unakwik District and 2 statistical areas in the Coghill District (Port Wells and the area south of Esther Island) were closed to gillnet fishing on the day of the survey.

Location records for the 9 KIMU killed as bycatch during the PWS observer program are unavailable. Wynne et al. (1991) reported that both birds killed in 1990 were taken in the same set with 6 MAMU in the Copper River District, although the specific location is not known. According to specimen records from the Burke Museum, 4 of the 9 KIMU killed in 1991 also were caught in the Copper River District (Fig. 37). The Copper River Delta is not considered KIMU habitat (Carter 2012) and there are no survey data available for this region.

<u>Yakutat</u>

Fishing effort

The Situk River had the greatest effort in the Yakutat Management Area and averaged 2048 permit-days per year, 4 times the average for Yakutat Bay, and almost 7 times the average for the Alsek River. The western shoreline of Yakutat Bay (Manby Shore) had the lowest effort, averaging just 34 permit-days per year. Effort for Dangerous Bay (including the remaining river drainages in the Yakutat District) averaged 96 permit-days per year, comparable to the entire Yakataga District (Fig. 38, 39).

The Alsek River was the first area to open and effort there was low but relatively constant through the season. Effort started out high in Yakutat Bay as soon as that area opened, then dropped steadily over the course of the season. Effort in the Situk had a bimodal distribution, with a smaller peak in July and a larger peak toward the end of the season in September. In the Manby Shore and the Dangerous River areas there was a small peak of effort in July; in the Yakataga District effort was concentrated in late August and September (Fig. 40).

KIMU distribution

We conducted one survey on 21–22 June 2010 and a second survey on 5–13 July 2010. Four transects (2 along the Manby Shore and 2 along the outer coast) could not be surveyed in July due to breaking waves, therefore we surveyed 2 transects in the upper bay instead. We counted 144 KIMU, 1,909 MAMU, 6 ancient murrelets and 239 unidentified murrelets during the June survey (Fig. 41). The largest aggregation of KIMU was near Knight Island, but KIMU also were well distributed along Manby Shore and along the outer coast near the Situk-Ahrnklin estuary (Fig. 41). We counted 104 KIMU, 1,100 MAMU, and 93 unidentified murrelets during the July survey (Fig. 42). Over half (58%) of KIMU were aggregated in 2 clusters northwest and southwest of Knight Island. We encountered fewer birds along the outer coast (mostly near the Phipps Peninsula), but more in the inner islands. Manby Shore was not surveyed, but we did observe several KIMU on the western side of the bay during the transit of the mouth (Fig. 42). Marbled murrelets were found in greater numbers in all areas where we observed KIMU except for the northern corner of Manby Shore in June and the pelagic waters off Manby Shore at the mouth of the bay in July (Fig. 41, 42).

The July 2009, USFWS survey observed 107 KIMU in 4 main areas: near Manby Shore in lower Yakutat Bay (37%), Russell Fjord (35%), upper Yakutat Bay (16%), and the lower bay southwest of Knight Island (11%; Fig. 43).

Gillnet distribution, overlap and bycatch

We flew 4 aerial surveys for gillnets during 2009 and 2010 (Table 3). Because the plane did not fly directly over the gillnets, aerial survey locations were typically offset from the true locations, however the general locations were the same as the nets sampled during the 2007–08 observer program (Fig. 44). In Yakutat Bay, gillnets were concentrated in 3 areas on the eastern side of the bay, all near the harbor entrance. The first area was Monti Bay, the second was off the tip of the Phipps Peninsula, and the third was on the bay side of Khantaak Island (Fig. 45). No KIMU were recorded off the Phipps Peninsula or in Monti Bay (Fig. 45), although MAMU were abundant there during both surveys and 5 MAMU were caught there as bycatch (Fig. 46). Four KIMU were recorded near Khantaak Island on the June survey (Fig. 45). MAMU were abundant here during the June survey, although not in July; 4 MAMU gillnet mortalities were detected in this area (Fig. 46). Along the western shoreline of Yakutat Bay (Manby Shore), at least 1 gillnet was present during each of the 4 aerial surveys (Fig. 44). KIMU were abundant here during the June murrelet survey and Kissling *et al*. (2011) also recorded relatively large numbers of KIMU near the ends of their transects in this area (Fig. 43, 45). The 1 KIMU bycatch mortality during the Yakutat observer program was killed here in mid-June (Fig. 45). Although marbled murrelets were 10 times as abundant here as Kittlitz's murrelets, there was no MAMU bycatch recorded in this area (Fig. 46).

Most of the gillnets along the outer coast of Yakutat were set in the rivers or estuaries with 3 exceptions. There were a few nets set in outside waters at the mouth of the Situk River during all 4 gillnet aerial surveys and 11 KIMU were recorded within 3 km of the mouth of the Situk River on June 22; a single KIMU was observed in the area in July (Fig. 45). Several nets also were set outside the mouth of the Dangerous River on 29 June 2009 and 5 KIMU were observed within 5 km of the mouth on the June murrelet survey (Fig. 45). The last exception was the area offshore of Ocean Cape. In 2008, a loophole in regulation combined with a lack of law enforcement personnel in the Yakutat area resulted in the development of an illegal gillnet fishery there. This area was subsequently closed to gillnet fishing by emergency order (Gordon Woods, ADF&G, personal communication) and no gillnets were observed in this area during any of the 2010 aerial surveys (Fig. 44). KIMU were observed in that area on the June, 2010, survey and MAMU were abundant during both surveys; 3 MAMU were killed as bycatch there during the observer program (Fig. 46).

Temporal and Spatial Overlap

Temporal overlap between Kittlitz's murrelets and gillnet fisheries was high. The gillnet season in the Gulf of Alaska occurs from May through October (Fig. 15, 16), which completely overlaps the KIMU breeding season (Day *et al*. 1999). In all areas except Yakutat both the set and drift gillnet fisheries peaked in late June or July (Fig. 15, 16), which also is when at-sea abundance of KIMU peaks following incubation (Agler *et al.* 1998, Kissling *et al*. 2007, Kuletz *et al.* 2008). There was variability in temporal overlap at the level of individual districts, statistical areas, bays or drainages. Prince William Sound and Yakutat had the greatest temporal variability in effort. Districts within Prince William Sound proper, where spatial overlap with Kittlitz's murrelets was greatest, also had the highest temporal overlap, whereas the Copper River District peaked earlier and the Bering River District peaked later in the season (Fig. 33). In Yakutat, the Dangerous and Alsek rivers showed the typical July peak in effort, but effort in the Situk River was greatest late in the season, in September (Fig. 40). In the main part of Yakutat Bay, effort was highest when the fishery opened in June and declined steadily over the course of the season. (Fig. 40).

At a coarse scale (the statistical reporting area), we found spatial overlap between Kittlitz's murrelets and gillnet fisheries in all 4 study areas. In Kodiak, KIMU were observed in 4 different bay systems (Alitak, Uyak, Uganik, and Viekoda) and 5 out of 19 statistical areas that allow gillnetting (Fig. 21). In Cook Inlet, KIMU were observed in 4 of 6 drift gillnet statistical areas in the southern half of the Central District, although none were observed in the set gillnet areas (Fig. 29). KIMU were observed in all of the Southern District set gillnet statistical areas in Cook Inlet (Fig. 30). In Prince William Sound, KIMU were observed in 2 out of 4 fishing districts and 3 out of 10 gillnet statistical areas within PWS proper (Fig. 35); no survey data were available for the Copper River or Bering Districts. In Yakutat, KIMU were observed in all 4 of the statistical reporting areas we surveyed: Yakutat Bay, Manby Shore, and at the mouths of the Situk and Dangerous rivers (Fig. 43).

Most of the coarse-scale overlap disappeared when examined at a finer scale. In Kodiak, there was fine-scale overlap in Alitak Bay, but in the western bays, most birds were observed in the upper arms of the western bays, areas that were either closed to fishing or had low effort and few or no gillnets sampled there (Fig. 20). In the Central District of Cook Inlet, multiple KIMU were observed in the SE and SW Drift areas in multiple years, including some in areas where gillnets also were sampled, but most were observed to the east or west of the gillnet concentrations (Fig. 29). In Prince William Sound proper there was almost complete spatial segregation of KIMU and gillnets. KIMU were found almost exclusively near the heads of the fjords during all surveys, whereas the nets in the Coghill District were set at the base of the fjord (Fig. 36). In Unakwik Inlet, most gillnets are set around or south of Miner's Bay (J. Botz, ADF&G Area Management

Biologist, personal communication), whereas KIMU were concentrated further north near the head of the inlet (Fig. 36). Although most of Yakutat Bay was open to gillnet fishing, nets were set in 3 highly localized areas near the harbor entrance; only 4 Kittlitz's murrelets were observed in any of these areas, all on the outside of Khantaak Island and all during the June, 2010 survey (Fig. 45). Along the outer coast of Yakutat, most nets were set in the rivers and estuaries and overlap was confined to small areas at the mouth of the Situk and Dangerous rivers (Fig. 45).

Discussion

For bycatch in commercial gillnet fisheries to be considered a conservation concern for Kittlitz's murrelets, it must first be demonstrated that birds and gillnets overlap in time and space. We would expect the greatest risk of bycatch where both fishing effort and KIMU abundance are high; we did not identify any such areas in any of the 4 study areas. Areas at lowest risk for gillnet mortality are those where there is spatial segregation of gillnet fishing and KIMU. These include the river and stream systems and most of Yakutat Bay in Yakutat, the heads of glacial fjords and the interior of Prince William Sound, and most of Lower Cook Inlet south of Anchor Point except for the southern shoreline of outer Kachemak Bay. Where overlap did occur however, bycatch was documented both in areas where fishing effort was high, but KIMU abundance low (Alitak Bay) and areas where fishing effort was low, but KIMU abundance high (Manby Shore). Both of these represent areas where KIMU frequented the shorelines of lower bays, and where gillnets also are typically concentrated. As expected, the AMMOP did not detect bycatch in areas where both fishing effort and KIMU abundance were low. Those areas include the upper arms of the western bays in Kodiak during August, the Southern District in Cook Inlet, Unakwik Inlet in Prince William Sound, and the mouths of the remaining major river drainages in Yakutat. There are insufficient survey data for the western bays in Kodiak during June and July or the Copper River Delta to assess the risk that bycatch might pose to birds in those areas. The total number of birds exposed to gillnets in any of the overlap areas is small.

Assessing the spatial and temporal distribution of gillnet fishing effort is problematic, both because ADF&G does not track fishing effort directly and because the spatial resolution of harvest data is not fine scale. We used the number of permits that reported catching fish each day to assess spatial and temporal patterns in fishing effort. This is a coarse estimate of actual effort and does not reflect the number of sets made during a day or the portion of a day that was actually fished. Furthermore, when we compared the number of set gillnets observed during our 5 aerial surveys to the number of permit holders who reported catching fish, on average only 70% of the nets that we observed reported catching fish in Yakutat (Table 3) and only 54% in Prince William Sound (Table 4). There are a number of possible reasons for this discrepancy, including permit holders not catching fish, not checking their nets daily, incorrectly reporting the date fish were caught, or illegally fishing 2 nets (G. Woods, ADF&G Area Management Biologist, personal communication). In the Prince William Sound drift gillnet fishery, the opposite occurred and we observed fewer nets than were reported to have caught fish (Table 4). We observed numerous gillnetters transiting the fishing grounds during our aerial survey; however, because our primary purpose was to determine the distribution of gillnets, we did not record vessels that were not actively fishing.

Statistical areas vary widely in size, ranging from small terminal harvest areas to large expanses of open ocean, and may contain large areas that are not fished, as well as a mix of suitable and unsuitable habitats for Kittlitz's murrelets. Plotting actual locations of gillnets, particularly in statistical areas that were very large (e.g., Yakutat Bay), allowed us to understand which portions of a statistical area were actually being fished. Apparent spatial overlap almost completely disappeared in all but a few localized areas when KIMU distribution was compared to actual gillnet locations. This was particularly noticeable in PWS, where KIMU consistently favored the upper reaches of bays and fjords, but gillnets were located near the base. M.E. "Pete" Isleib, a commercial fisherman and ornithologist who fished extensively in Prince William Sound in the 1970s, also noted that KIMU were most abundant in the heads of the fjords, outside the areas where fishing occurred; he concluded therefore that "conflicts and bird mortalities are minimized" (Carter 2012). The same appeared to be true in the western bays of Kodiak, although more survey data are needed to confirm this pattern holds during June and July. In Yakutat Bay, only a small portion of the bay was actually fished (Fig. 44).

Using overlap to assess the risk of bycatch to KIMU depends on the assumption that the distributions of both KIMU and gillnets are relatively stable over time. In the 3 study areas where locations of sampled gillnets were recorded, we found little variation in gillnet distribution from month to month (Figs. 20, 26, 44). There was greater variation at an annual scale, because in some years certain areas were either closed to fishing or not sampled by the AMMOP. Although only a single snapshot sample of gillnet locations was obtained for Prince William Sound, gillnet distribution there is strongly influenced by hatchery and net pen sites and "pinch points" where fish are known to aggregate and also remains similar from one season to the next (G. Hollowell, ADF&G Area Management Biologist, personal communication).

There was greater variability in KIMU distribution over time and the pattern differed among study areas. KIMU distribution is most stable in Prince William Sound, where all surveys found KIMU aggregated at the heads of fjords and bays (Fig. 35). Additional surveys in the late 1990s that surveyed 4 of those fjords at 3 different times during the May–August breeding season also found KIMU concentrated near the heads (Day and Nigro 1999). In Cook Inlet, multiple surveys identified several consistent aggregations of KIMU; most of those surveys were conducted in late July and early August (1 was in June). Although we have little or no information on KIMU distribution in May, June, or late August, 87% of the total fishing effort in Cook Inlet occurred during the 6-week period from late June to early August, roughly the period covered by the surveys. In Yakutat, all 3 surveys were conducted during a 4-week period in late June and early July. Surveys in nearby Icy Bay that extended into August found a shift in KIMU distribution over time, from the mouth of the bay to the upper fjords (Kissling *et al*. 2007). There was some evidence of a change in distribution from the June to July survey in 2010; however, this was confounded by rougher surf conditions in July, which resulted in different coverage areas for the 2 surveys (Fig. 43). If KIMU in Yakutat Bay also shift from the mouth to the upper fjords over time, this would reduce conflicts with gillnet fisheries, however additional survey effort would be needed in July and August to determine this. In Kodiak, there has not been enough survey effort during the peak season to determine abundance or distribution patterns.

Although at the finest scale there was minimal overlap between gillnets and Kittlitz's murrelets, bycatch mortalities did occur. Most of the documented bycatch of Kittlitz's murrelets (9 of 11 birds) occurred during the 1990–1991 observer program in Prince William Sound. All 6 of the KIMU for which a location is known were taken in the Copper River District; 2 were taken in June, 2 in July and dates for the remaining 2 birds are not known. This was unexpected, because the Copper River Delta is not considered KIMU habitat and neither KIMU nor MAMU are normally abundant there except for a brief period in early September, during fall migration (Carter 2012). Fisherman did report higher than normal numbers of murrelets and entanglements in the Copper River District in 1990 and 1991 (Wynne 1991, 1992); whether this increase was a temporary phenomenon related to the 1989 Exxon Valdez oil spill or other factors is not known.

During the Kodiak AMMOP, 1 Kittlitz's murrelet was killed in a gillnet in mid-July in Alitak Bay (Fig. 22). Surveys of Alitak bay in May and August observed no KIMU, but a single survey in June 2011, observed 10 birds (Fig. 21): this single survey comprised 30% of all KIMU observations in gillnet areas and 22% of all KIMU observations the Kodiak Archipelago during 1991–2011. Whether the relatively large number of sightings was due primarily to survey timing (June) or design (a mix of shoreline and offshore transects) or both is unclear. Most (6/8) observations of multiple KIMU during all surveys were from June; several of those groups (including the largest group of 6 KIMU) were offshore (Fig. 21). There have been few systematic surveys of the western bays in June and July. In August, KIMU on the west side of Kodiak appear to be strongly associated with the heads of fjords (Fig. 21), similarly to KIMU in areas such as PWS (Day *et al*. 2000, Kuletz *et al*. 2011b) and Kenai Fjords (Arimitsu *et al*. 2011). Gillnetting was either prohibited in those areas or effort was very low, which would minimize encounters between KIMU and gillnets. The 2 observations from May and June also were both in those same upper arms and a survey of the western bays by Madison *et al.* (2011) in late July of 2009 observed 3 KIMU in the upper arms of Uganik Bay, beyond where any gillnets were sampled. However, the only July observation from the 1991-2011 Kodiak NWR surveys was of a juvenile KIMU in the lower reaches of Uganik Bay (Fig. 21), where fishing effort was high and gillnets were sampled by the AMMOP during 5 out of 7 months (Fig. 20). More information is needed on KIMU distribution and abundance in the western bays during June and July to fully assess the risk of bycatch on that side of the island.

In Yakutat, 1 Kittlitz's murrelet was killed in a gillnet in mid-June at Manby Shore. Although fishing effort in the Manby Shore area was minimal, KIMU were abundant there during the June survey and this was the only area we observed KIMU in the immediate vicinity of nets. Interestingly, no marbled murrelet bycatch was detected here, although marbled murrelets were 10 times as abundant as KIMU in this area during the June 2010, survey (Fig. 41). Gillnet sampling effort at Manby Shore was low; during the 2 years of the Yakutat AMMOP only 25 hauls were observed over 2 days. The fact that bycatch of KIMU, but not MAMU, was detected in an area with both very low fishing effort and very low sampling effort, suggests that KIMU may be more vulnerable than MAMU to entanglement in gill nets when they do encounter them. This may not be a general rule, however; Pete Isleib observed in PWS that the few KIMU present in the areas being fished "appear to have a greater net avoidance capability than Marbled Murrelets," although he did not elaborate (Carter 2012).

Our assessment of overlap between KIMU and gillnets was based on KIMU survey data that was collected during daylight hours. KIMU are known to leave the fjords at night, although it is unknown where they go. Marbled murrelets move to deeper waters at night (Haynes *et al*. 2010) and at least some KIMU do as well, since that is where researchers typically capture them (M. Kissling, USFWS, personal communication, A. Allyn and A. McKnight, personal communication). This would minimize overlap with set gillnets, which can only be set in shallow waters, but could lead to overlap with drift gillnets, which can be fished in deeper waters. Drift gillnets in Cook Inlet were concentrated in the deeper waters in the middle of the inlet, however the driftnet fishery there is generally restricted to daylight hours (Manly 2006). By contrast, in PWS, all of the drift gillnets observed in the Coghill and Montague Districts were located within 1 km of the shore; most had the buoy on the free end resting on the shore, which would minimize overlap with KIMU if birds moved to deeper waters at night. During 30 June to 14 July 2009, there was a telemetry receiving station on the northwest shore of Esther Island (in the Coghill District) that picked up signals from multiple radiotagged KIMU on multiple nights. Although the exact location of the birds could not be determined, the infrequent and erratic nature of the signals suggested the birds were most likely passing quickly through the area or spending time at the outer edge of the receiver coverage area (which extended more than halfway across Port Wells), as opposed to moving closer to gillnetting activity along the shore (A. Allyn and A. McKnight, unpublished data).

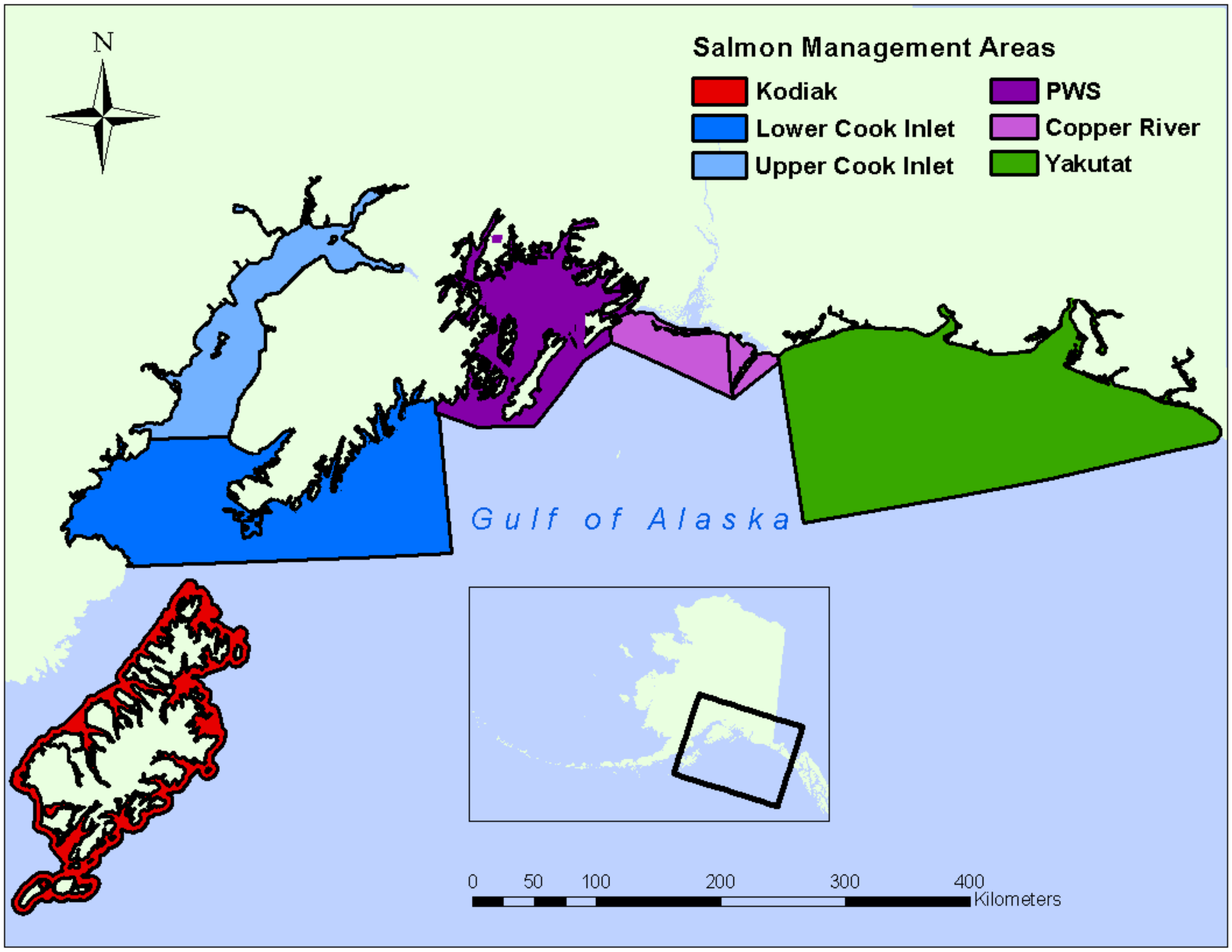

Figure 1. Salmon management areas where gillnet fisheries were monitored by the Alaska Marine Mammal Observation Program.

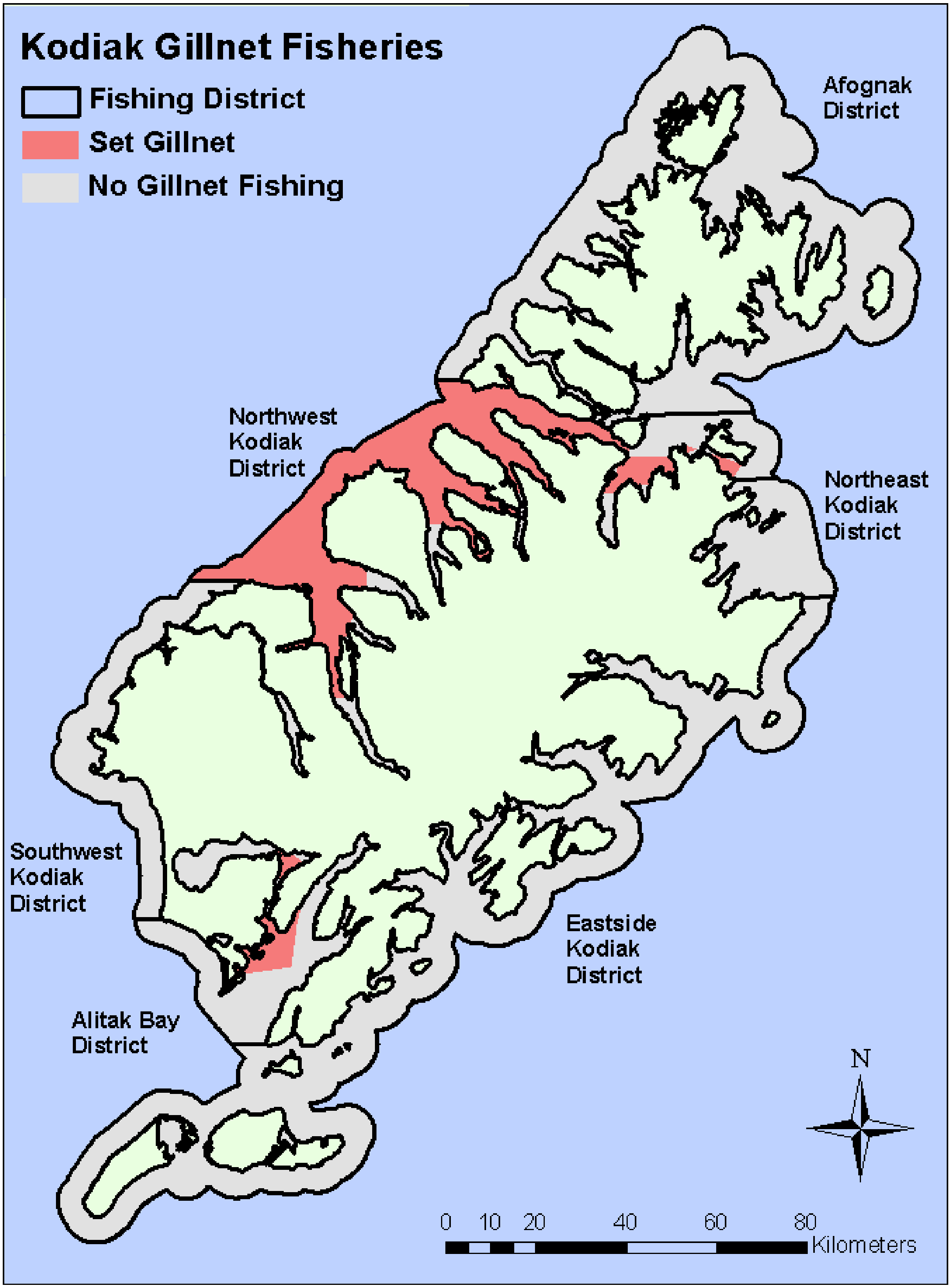

Figure 2. Fishing districts and areas open for set gillnet fishing in the Kodiak Management Area.

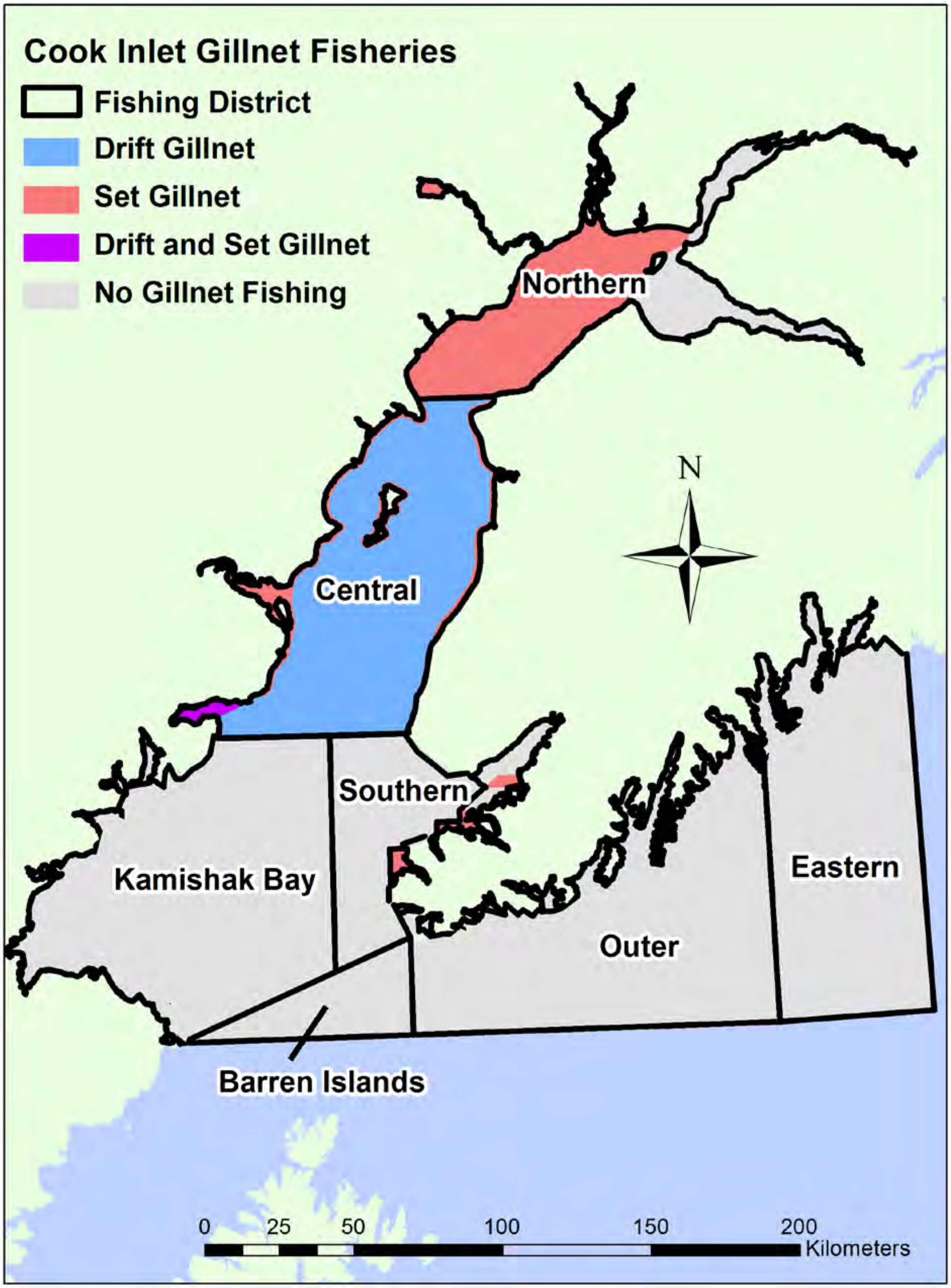

Figure 3. Fishing districts and areas open for drift or set gillnet fishing in the Upper and Lower Cook Inlet Salmon Management Areas.

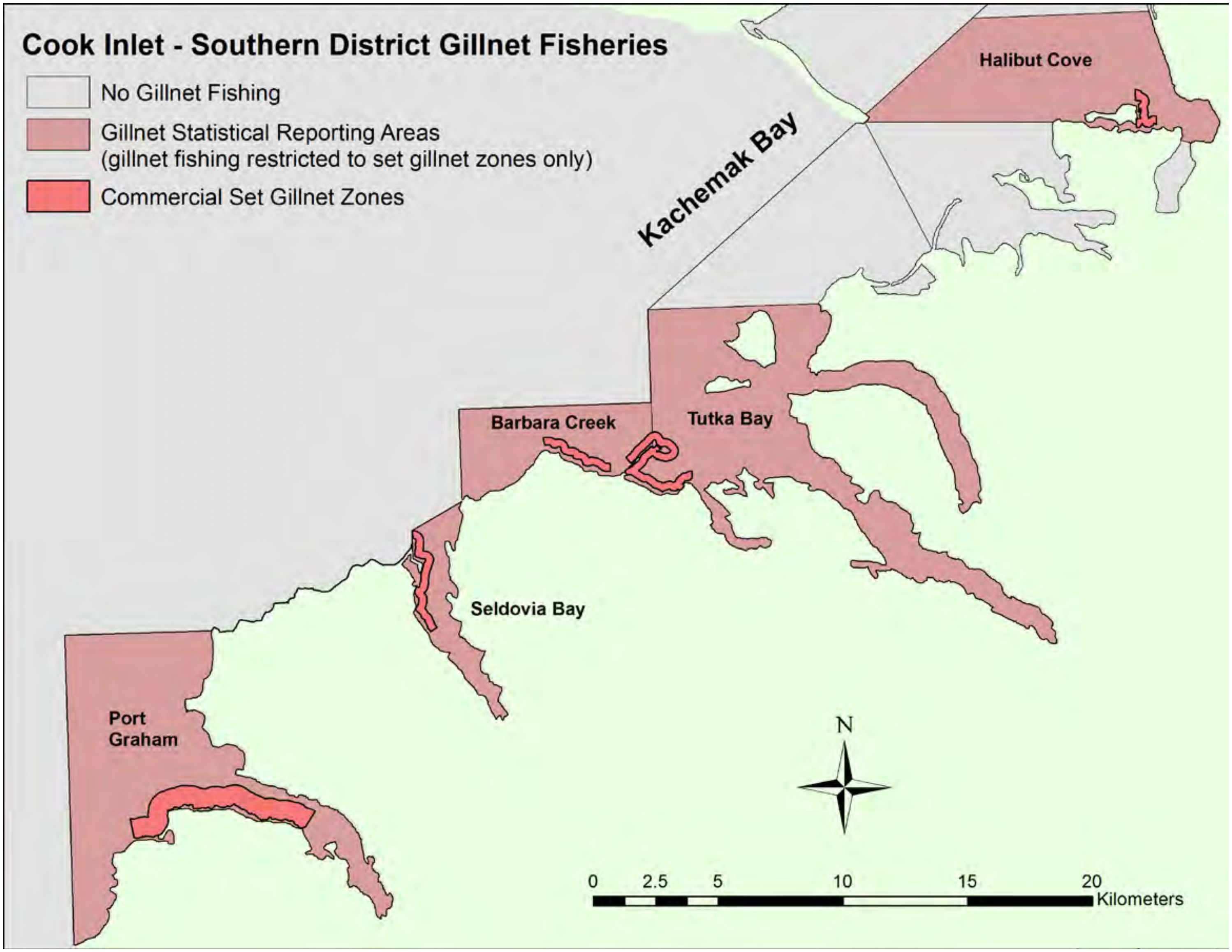

Figure 4. Commercial set gillnet zones in the Southern District.

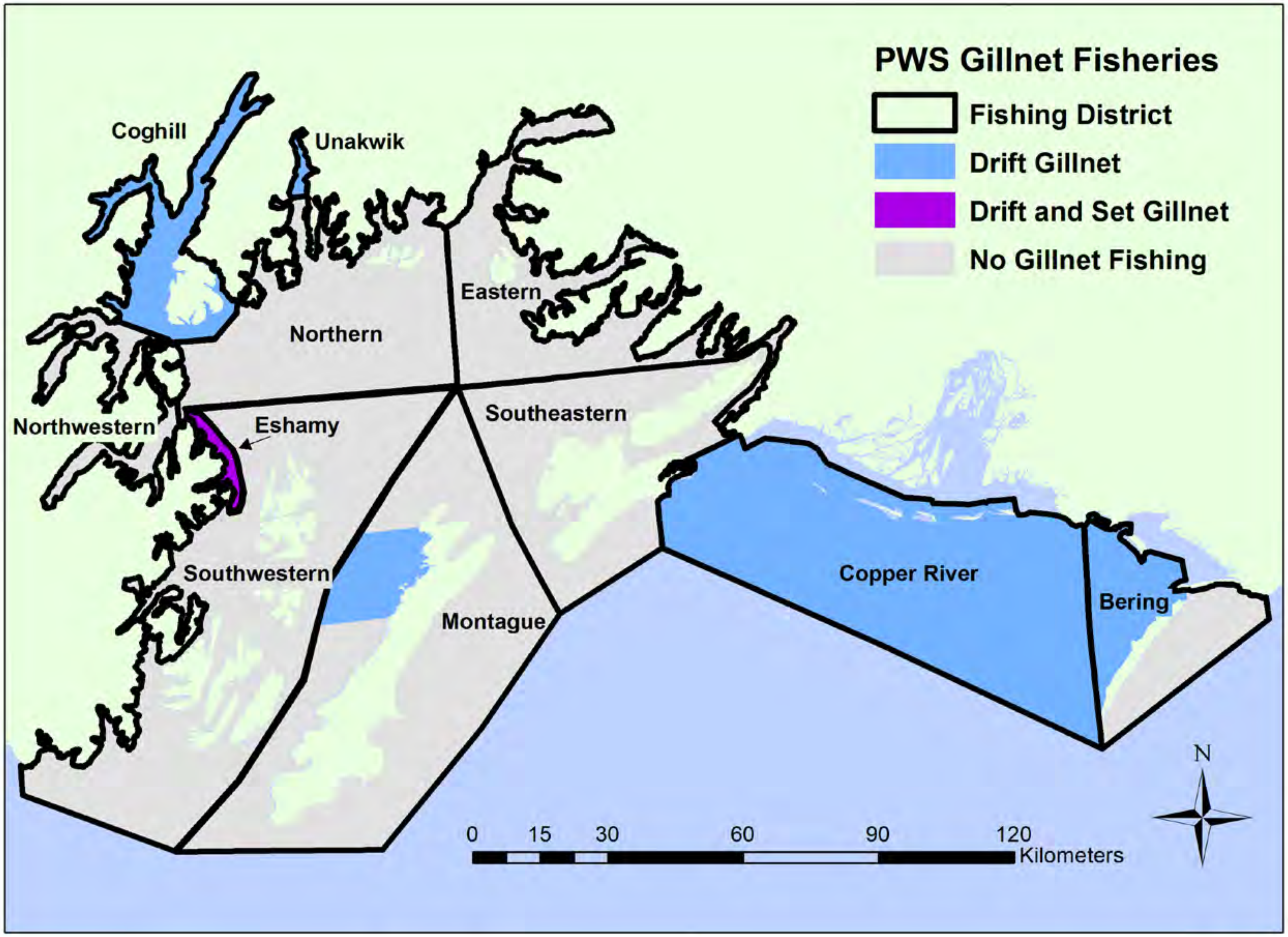

Figure 5. Fishing districts and areas open for drift or set gillnet fishing in the Prince William Sound and Copper River Salmon Management Areas.

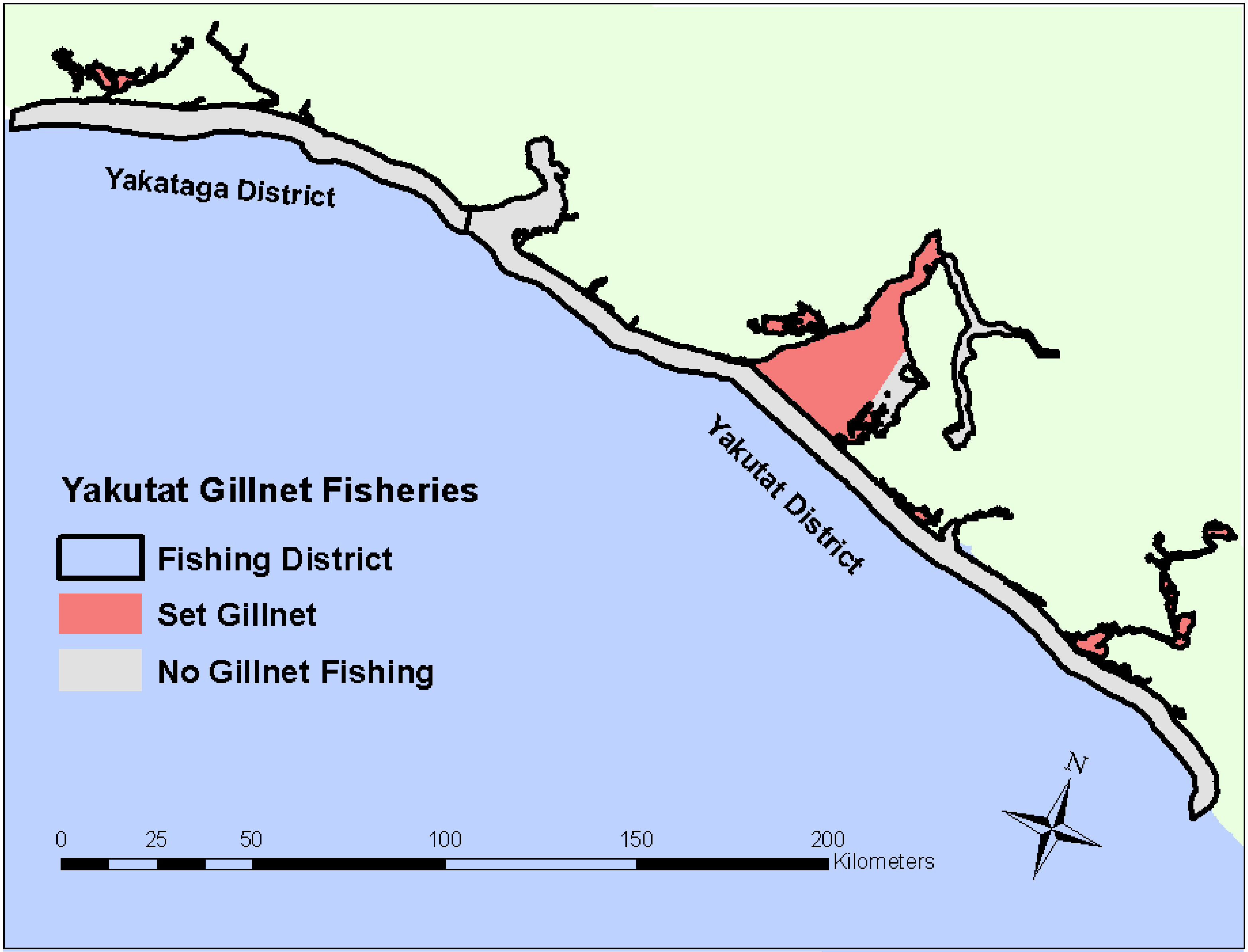

Figure 6. Fishing districts and statistical areas open for set gillnet fishing in the Yakutat Salmon Management Area.

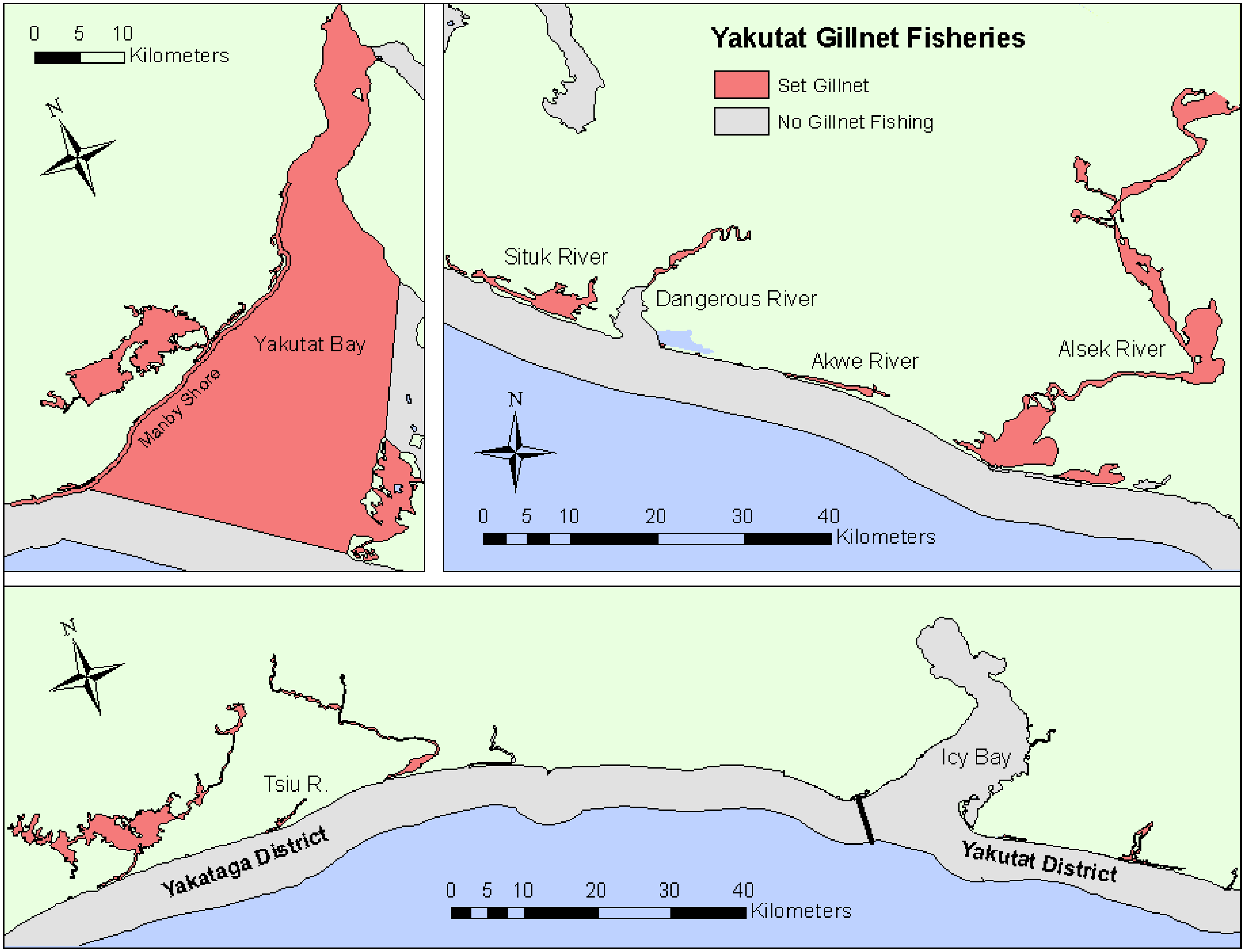

Figure 7. Close-up of areas open for set gillnet fishing in the Yakutat District (top panels and far right of bottom panel) and Yakataga District (bottom panel).

Figure 8. Drift gillnets (top of photo) and set gillnet (bottom of photo) in Prince William Sound. Set gillnets are anchored in place and often have a "hook" at one end (bottom net). Drift gillnets are attached to the boat on one end, with the other end floating free. In practice, the free end of the net may end up on or near the shore similar to a set gillnet, as is the case for the 2 drift gillnets pictured in the top of the photo above.

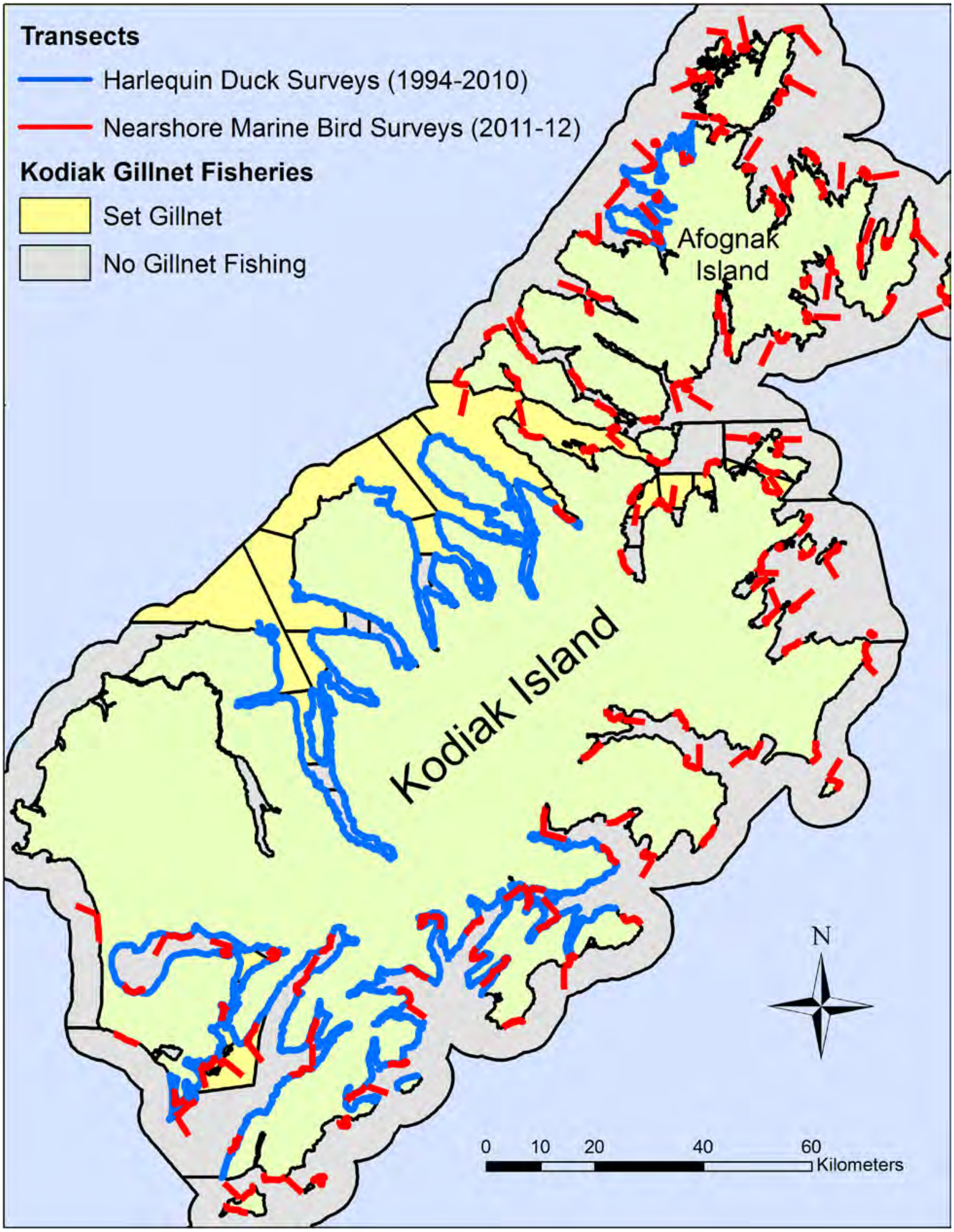

Figure 9. Survey transects used to determine KIMU distribution relative to gillnet fishing areas in the Kodiak Management Area.

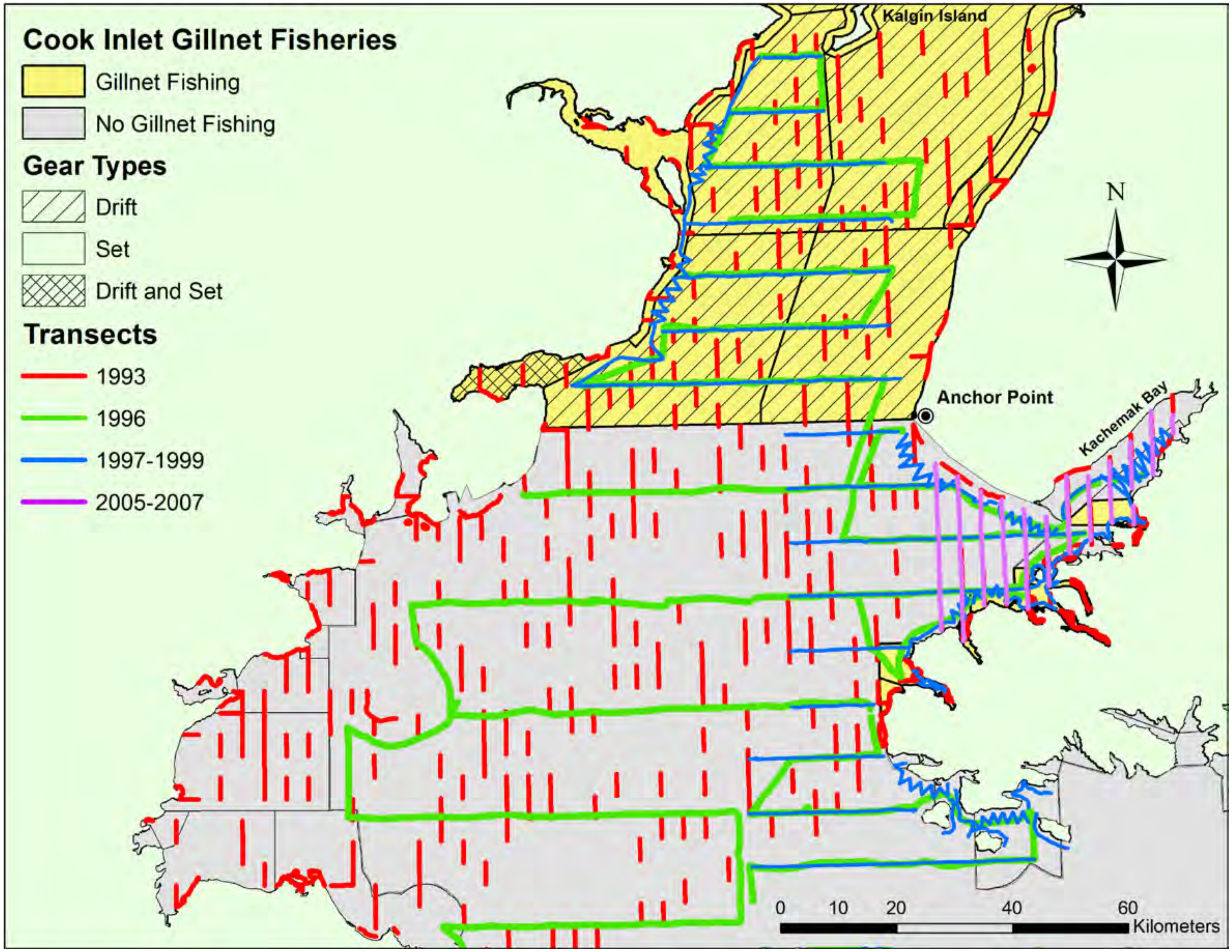

Figure 10. Survey transects used to determine KIMU distribution relative to gillnet fishing areas in the Cook Inlet Management Area.

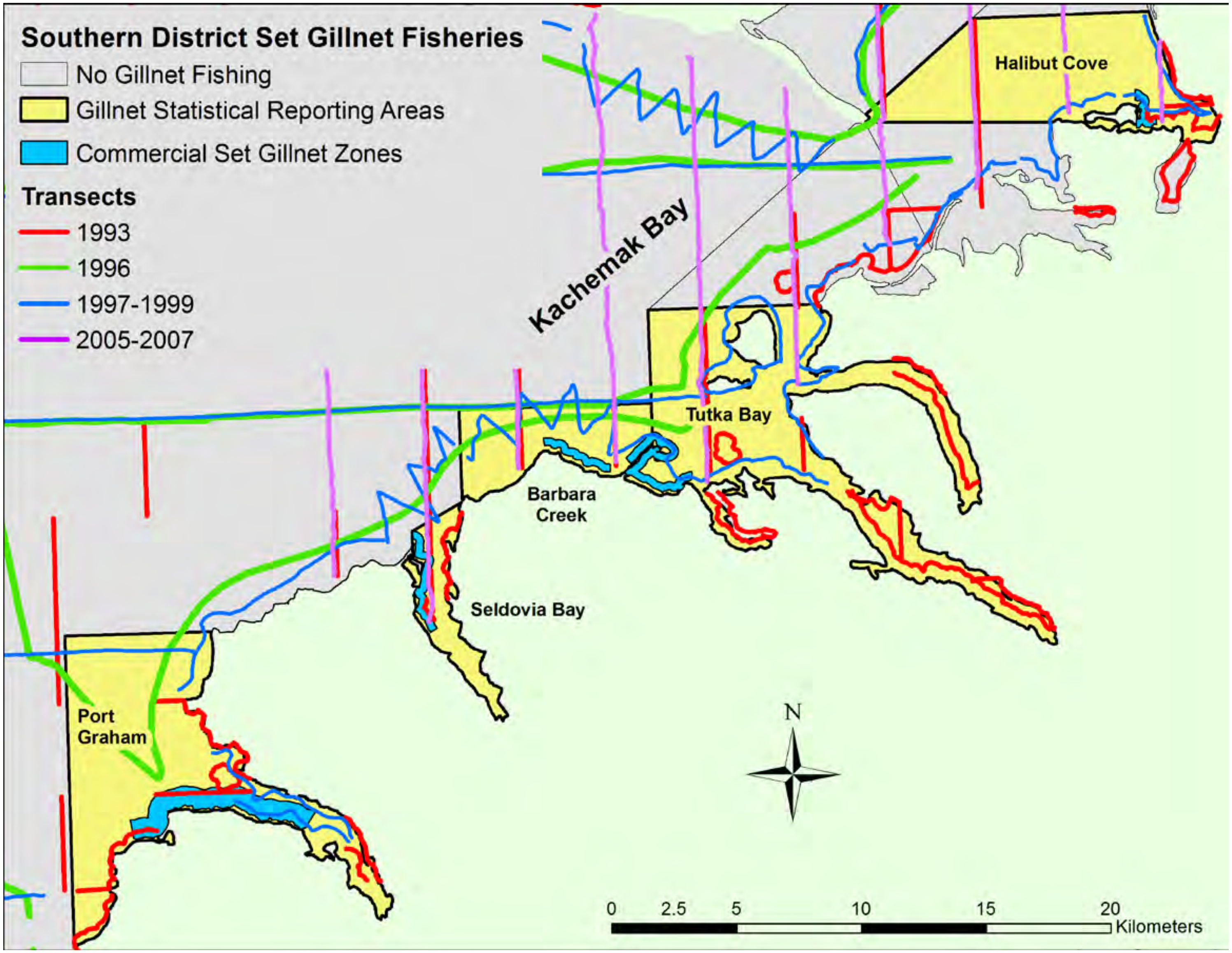

Figure 11. Survey transects used to determine KIMU distribution relative to gillnet fishing areas and commercial set gillnet zones in the Cook Inlet Management Area.

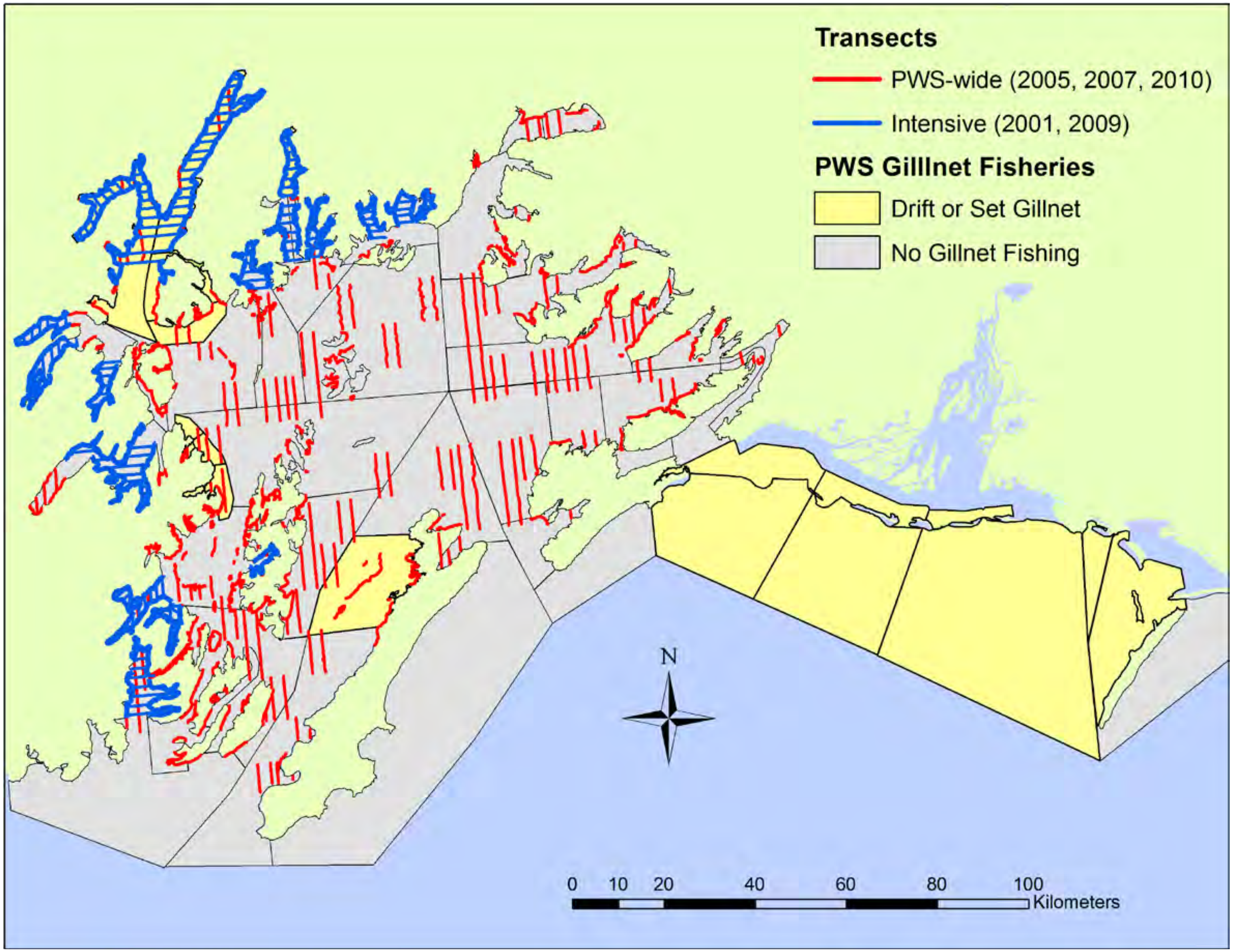

Figure 12. Survey transects used to determine KIMU distribution relative to gillnet fishing areas in the Prince William Sound Management Area.

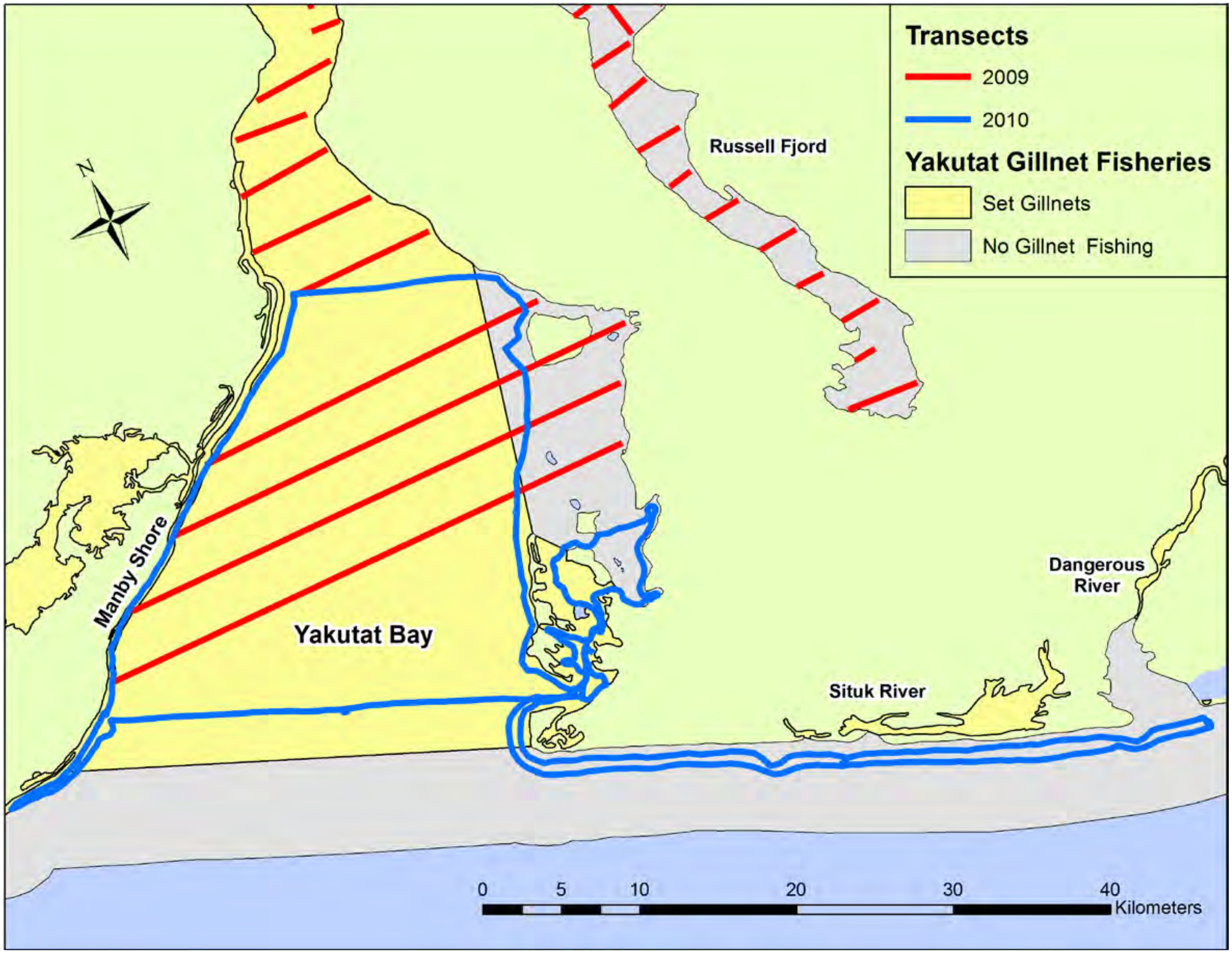

Figure 13. Survey transects used to determine KIMU distribution relative to gillnet fishing areas in the Yakutat Management Area.

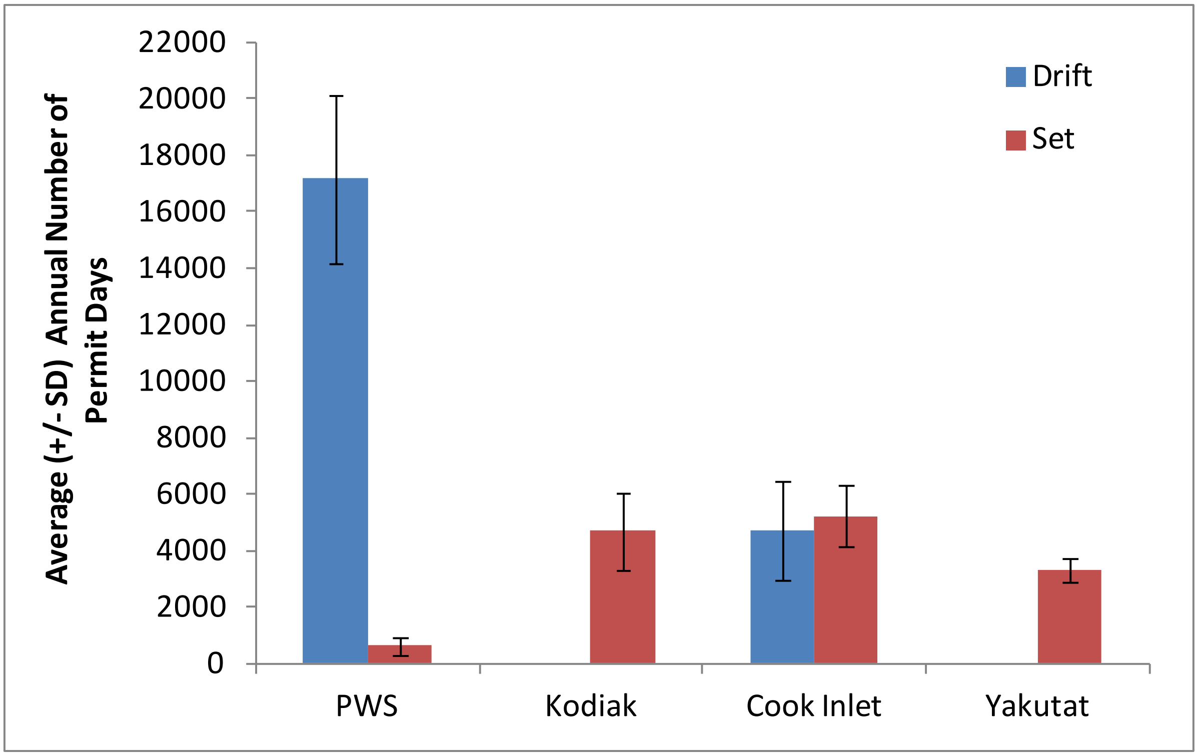

Figure 14. Average annual fishing effort (2000–2010) in each salmon management area, by gear type.

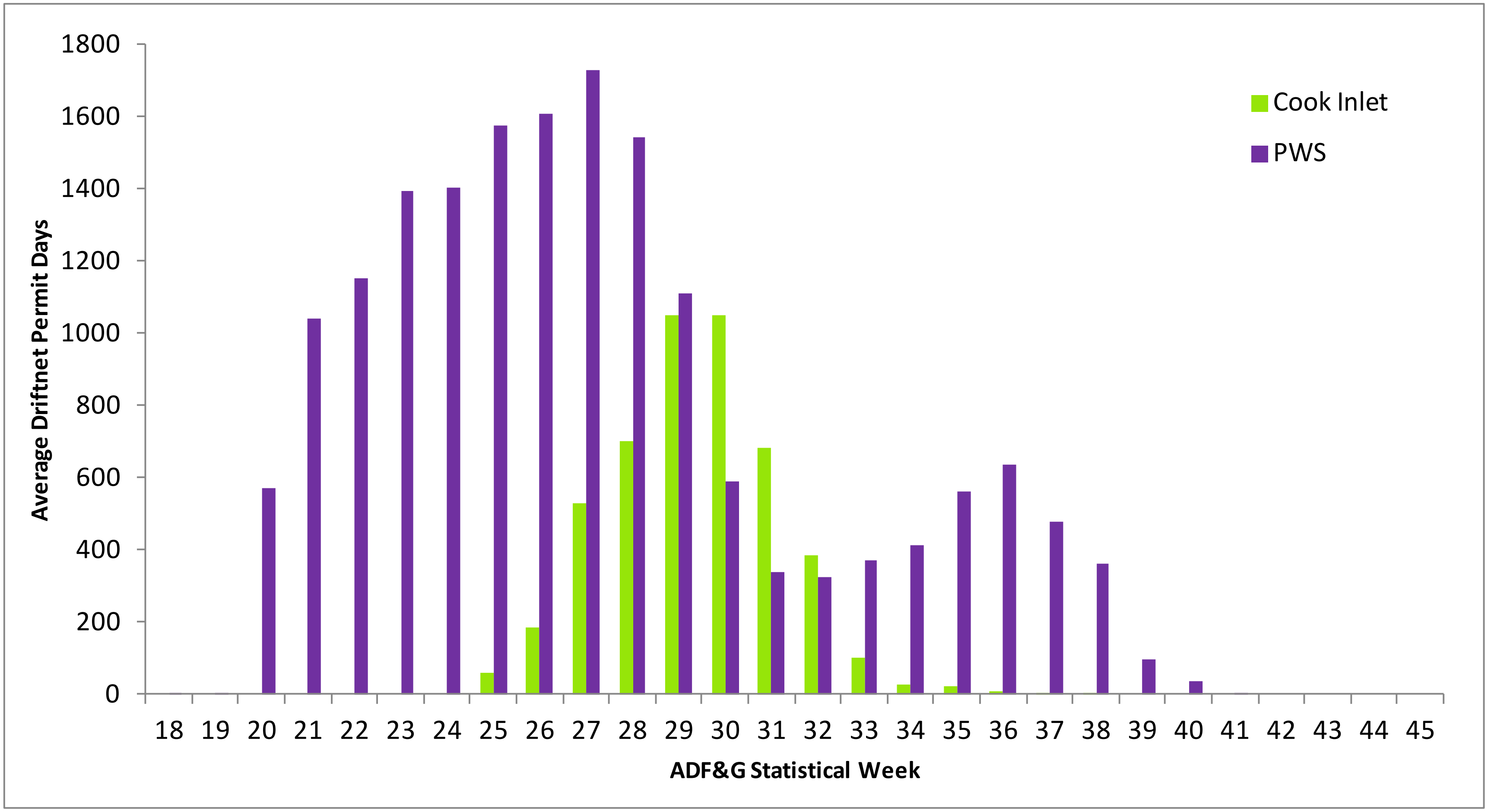

Figure 15. Seasonal distribution of fishing effort for drift gillnet fisheries in the Gulf of Alaska, 2000–2010, by salmon management area and statistical week.

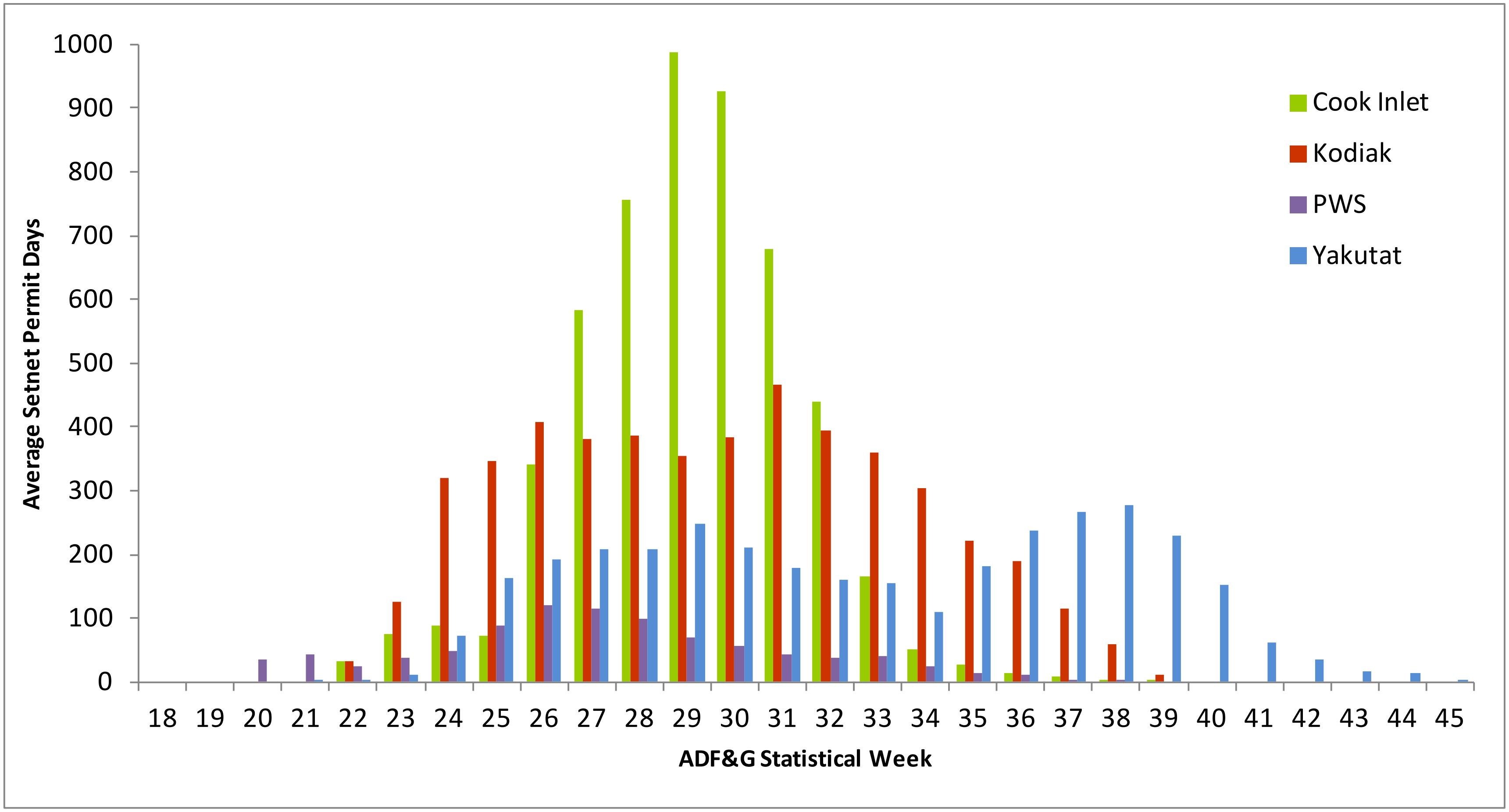

Figure 16. Seasonal distribution of fishing effort for set gillnet fisheries in the Gulf of Alaska, 2000–2010, by salmon management area and statistical week.

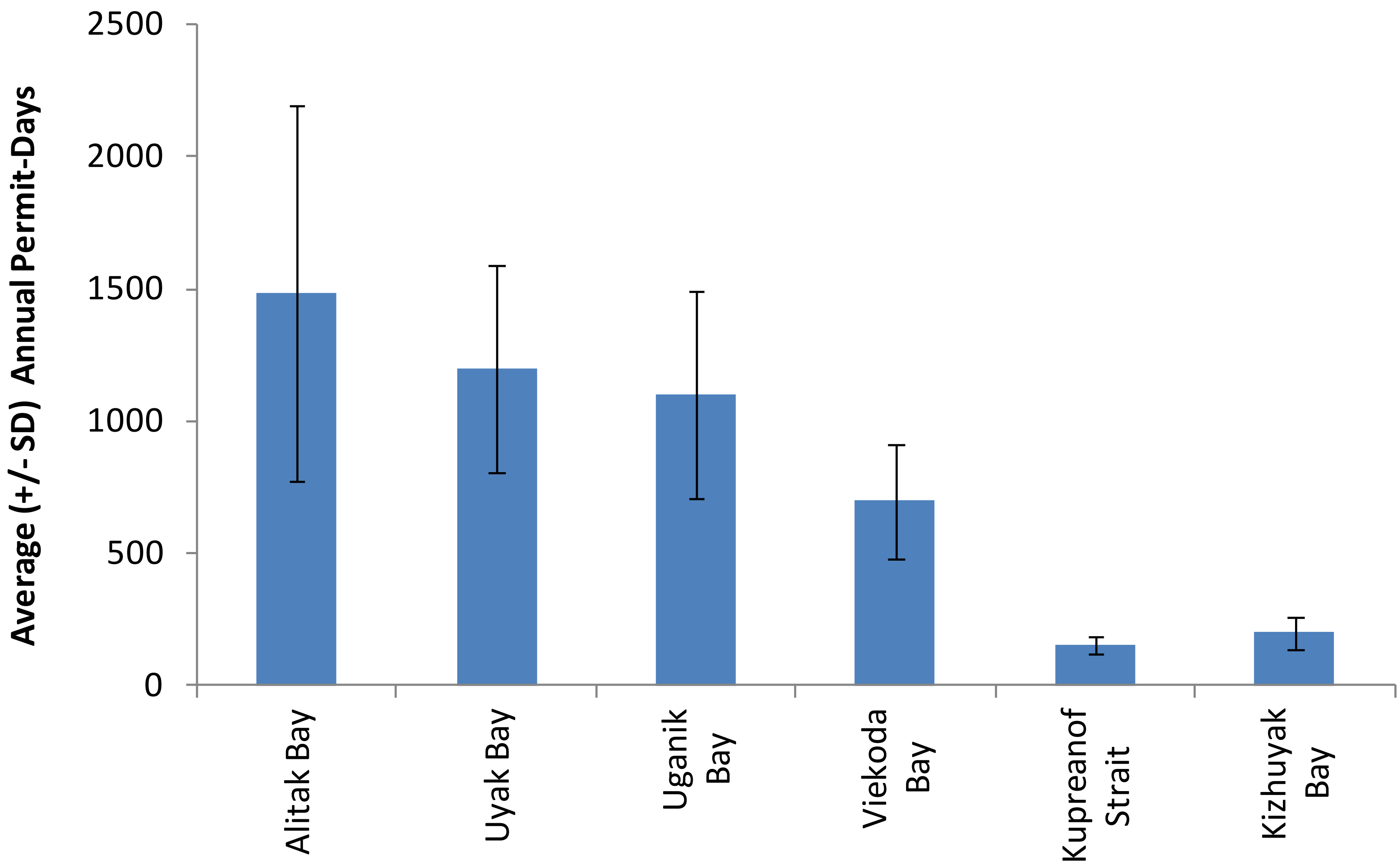

Figure 17. Annual fishing effort in the Kodiak Management Area, 2000–2010, by bay.

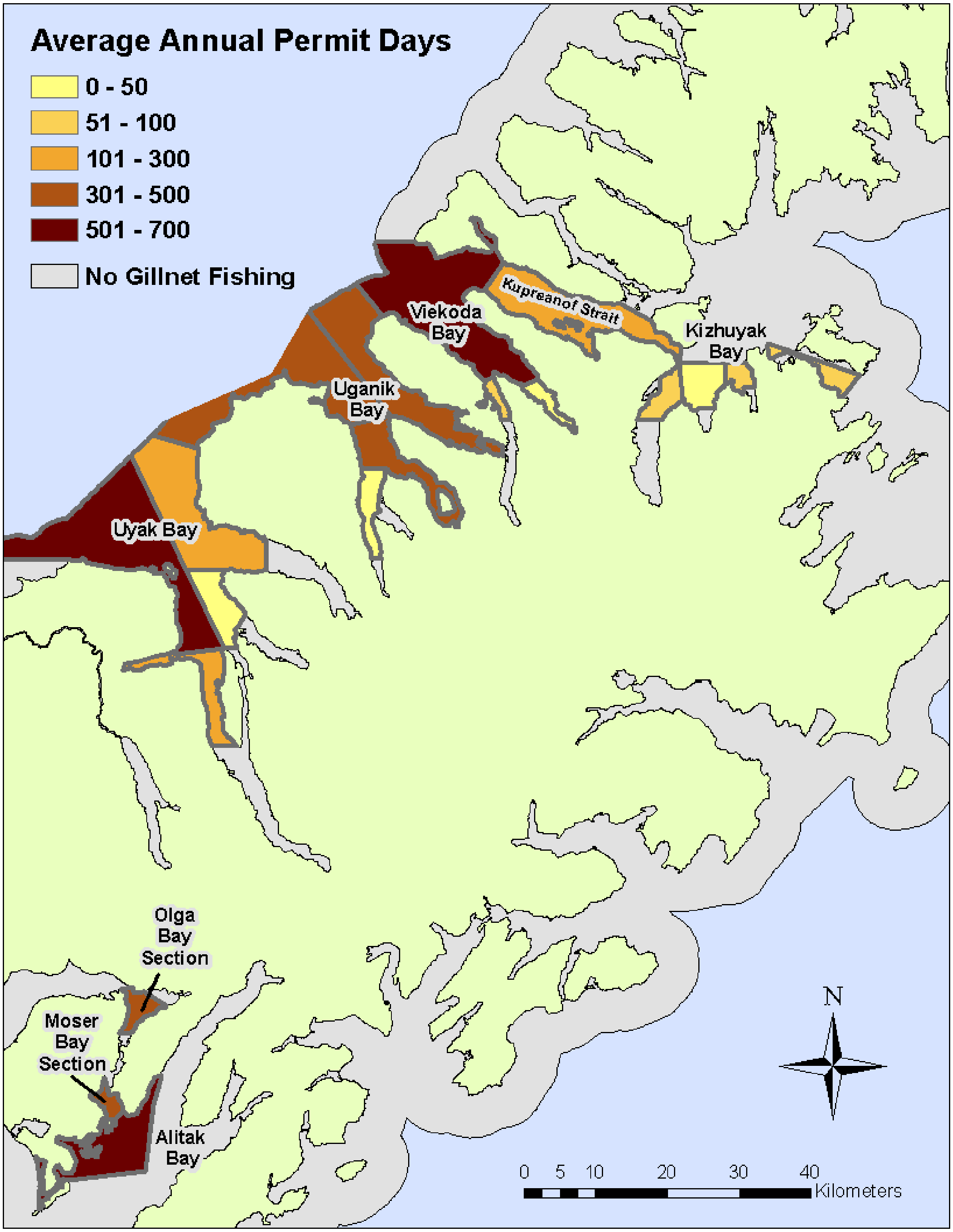

Figure 18. Distribution of annual fishing effort for the Kodiak Management Area, 2000–2010, by statistical reporting area.

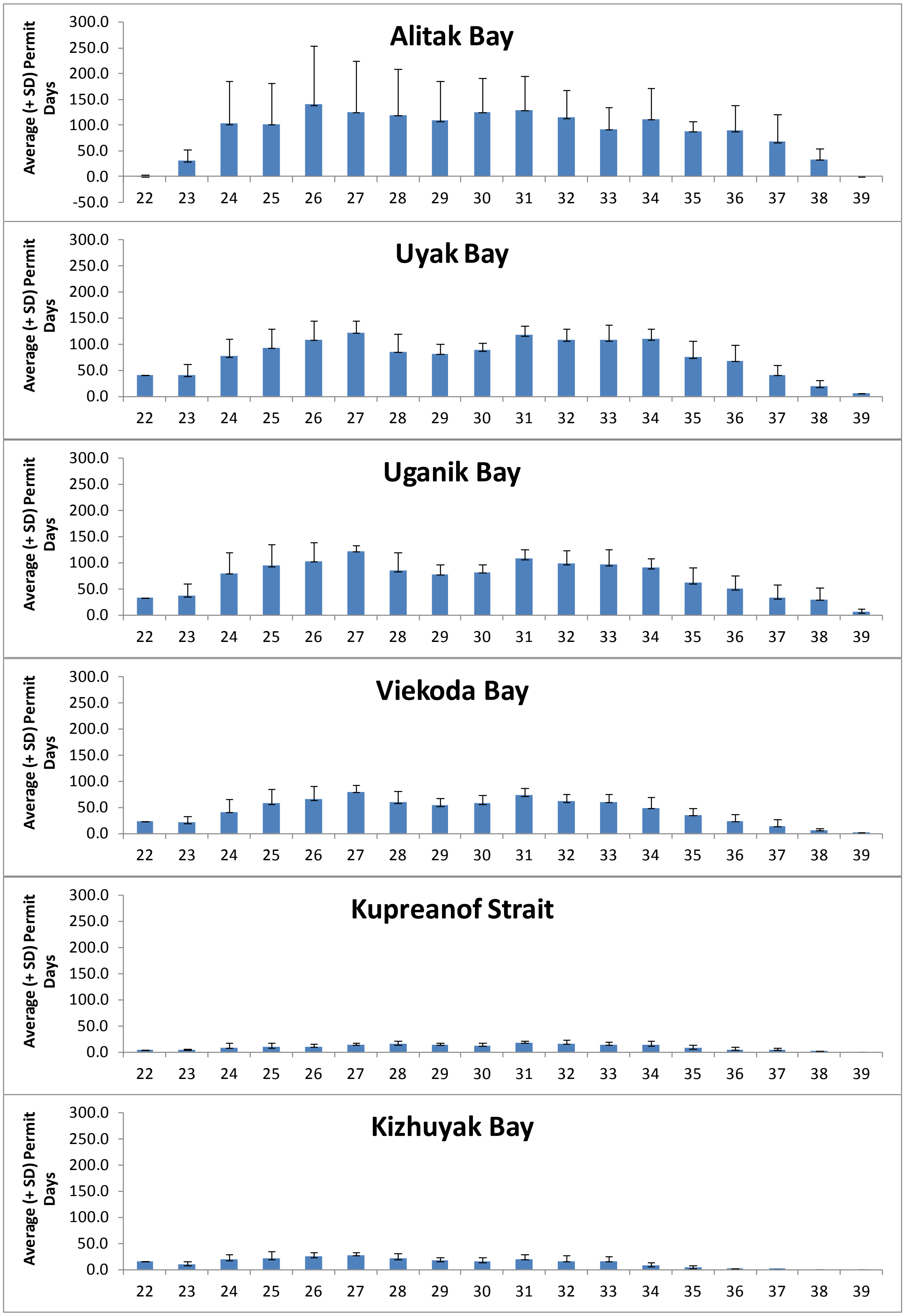

Figure 19. Seasonal distribution of fishing effort in the Kodiak Management Area, 2000–2010, by bay and statistical week.

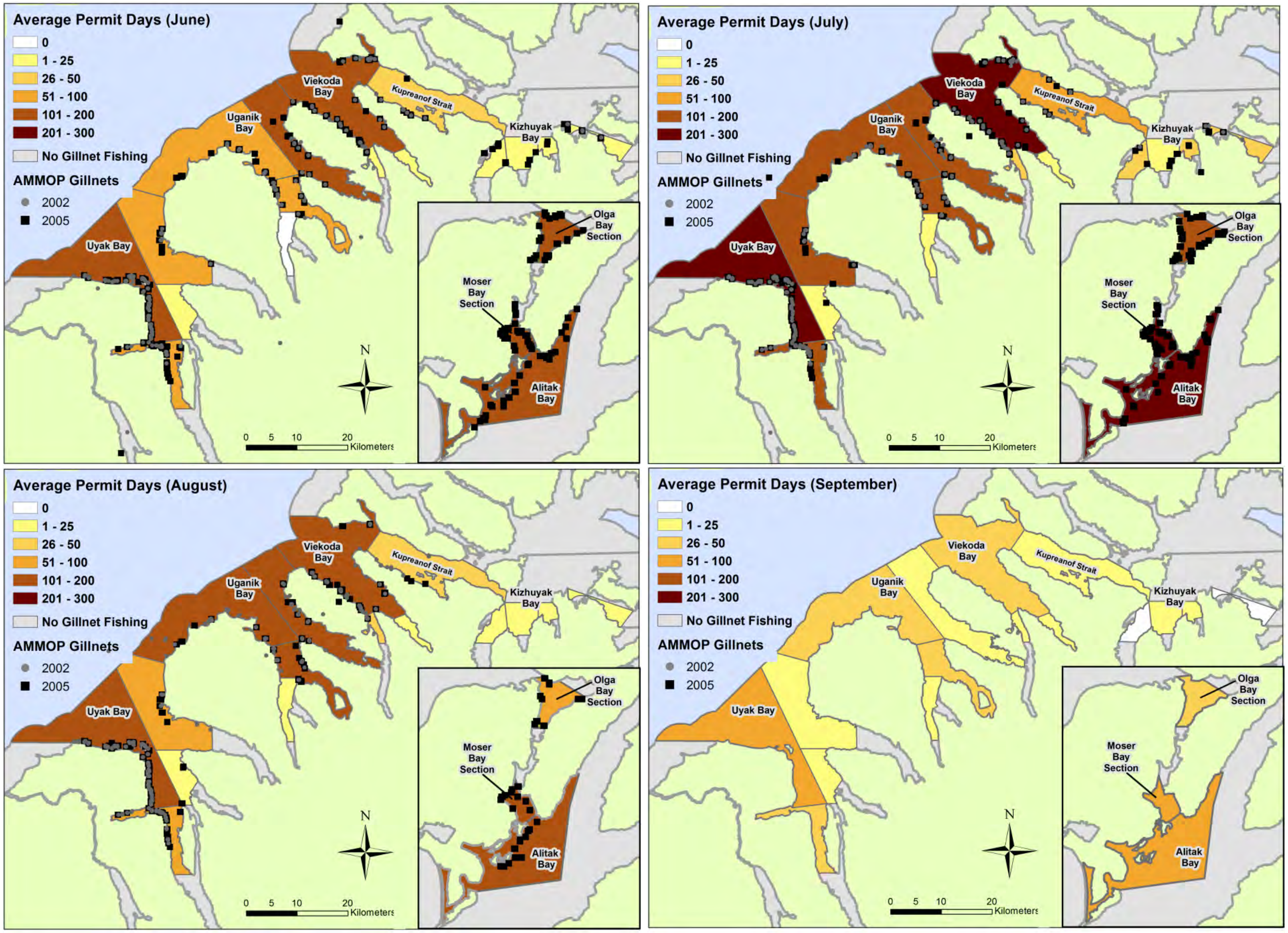

Figure 20. Monthly distribution of fishing effort and gillnets sampled by the AMMOP in the Kodiak Management Area.

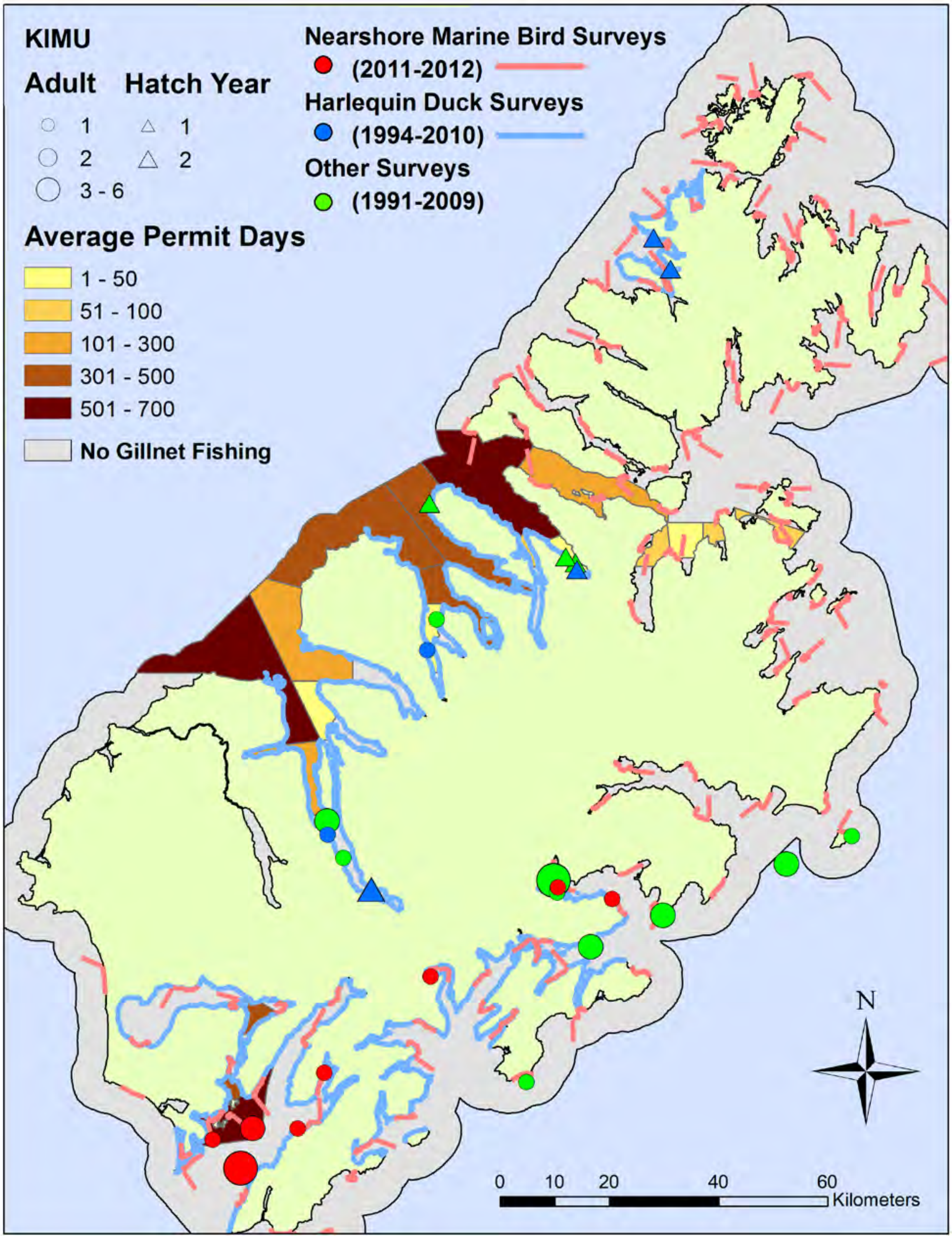

Figure 21. Locations of Kittlitz's murrelets from various marine surveys conducted by the Kodiak NWR during 1991–2011.

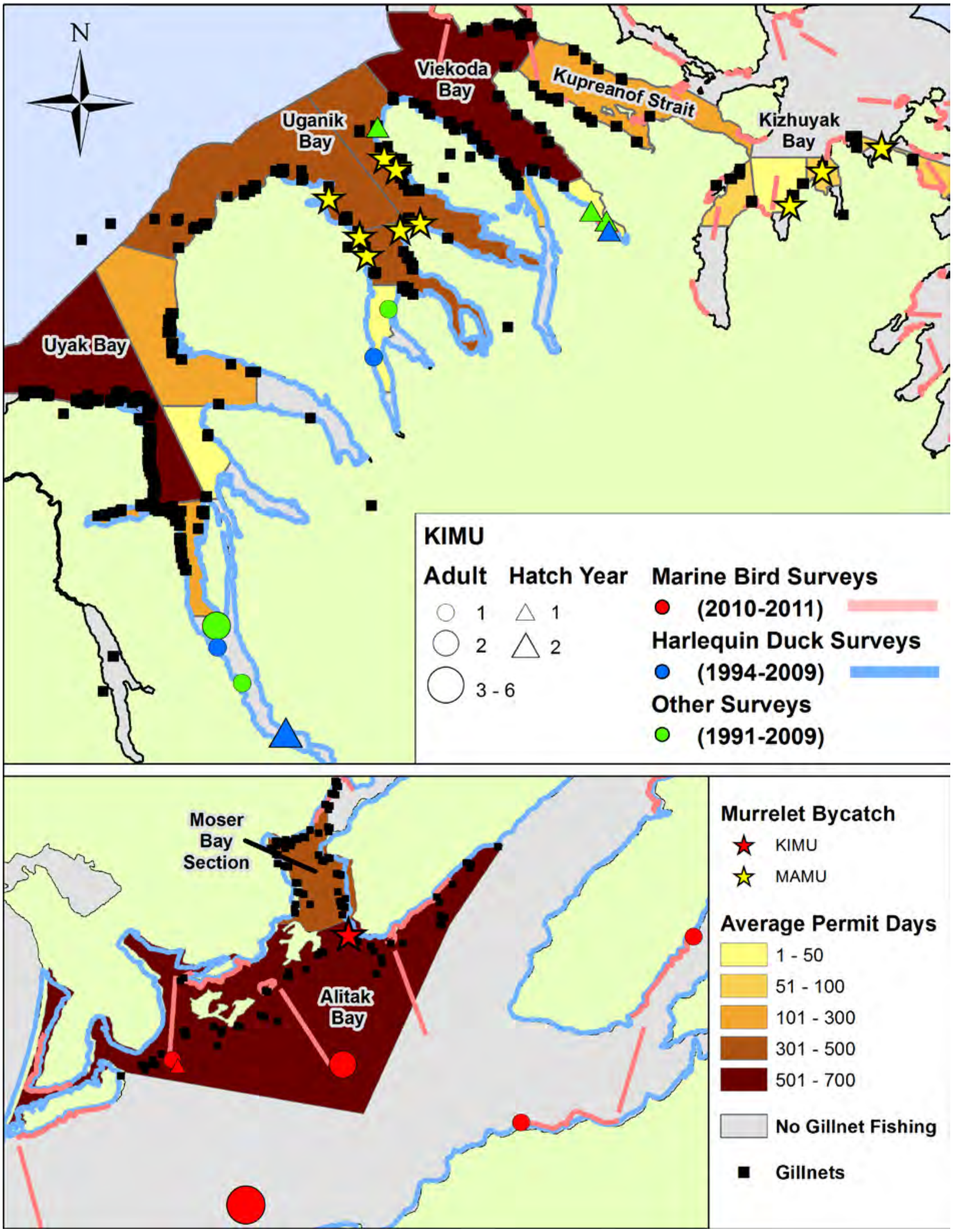

Figure 22. Distribution of gillnets sampled during the Kodiak AMMOP relative to Kittlitz's murrelet survey locations and Kittlitz's and marbled murrelet bycatch locations.

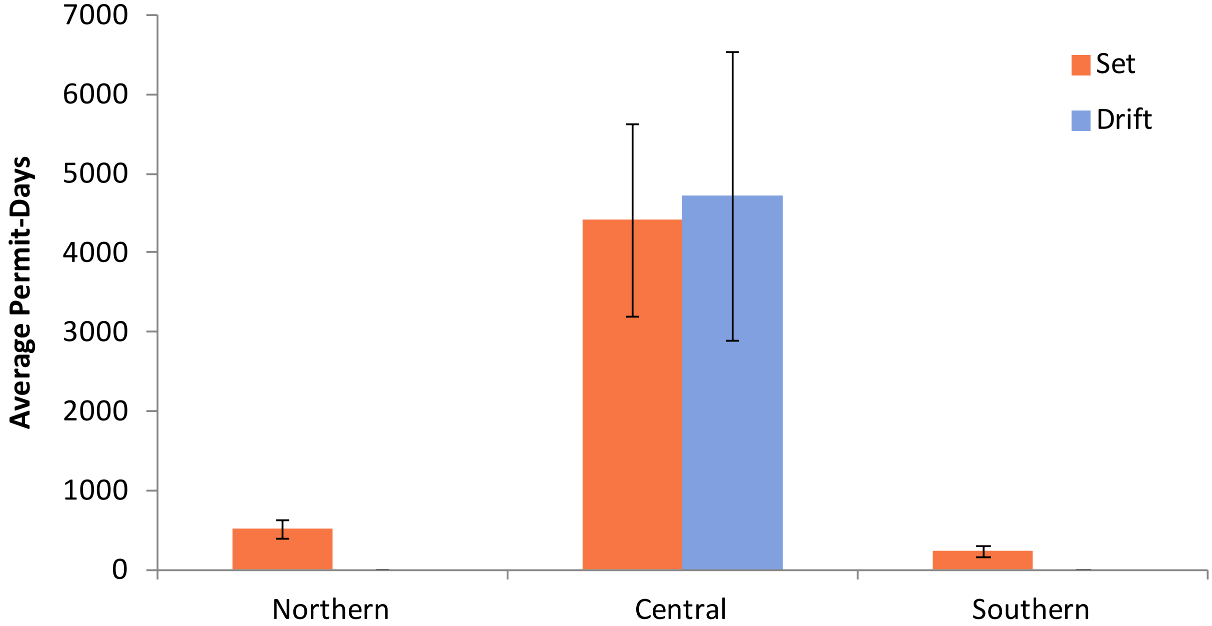

Figure 23. Annual fishing effort for the Cook Inlet Management Area, 2000–2010, by district and gear type.

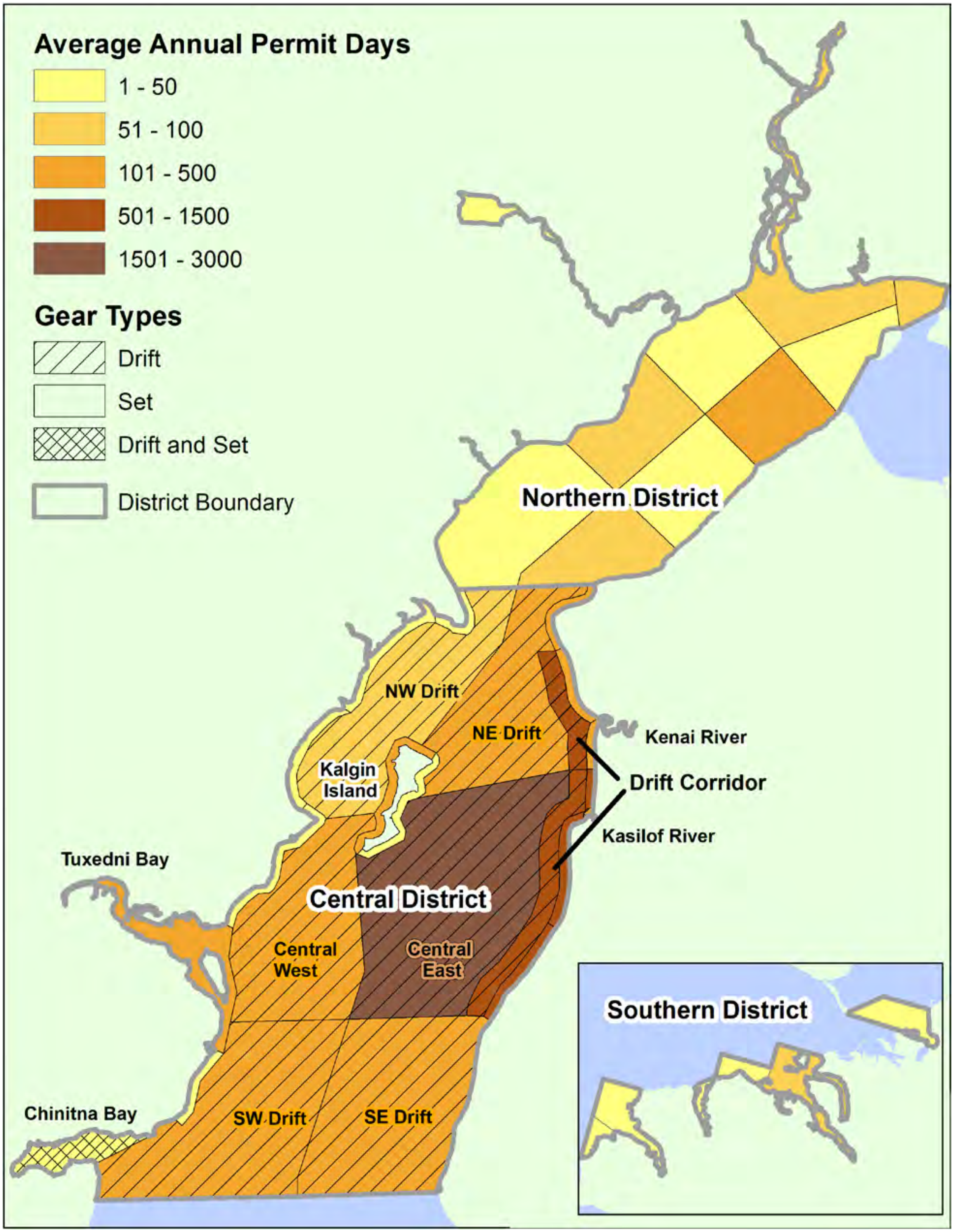

Figure 24. Distribution of annual set and drift gillnet fishing effort in the Cook Inlet Management Area, 2000–2010, by statistical reporting area.

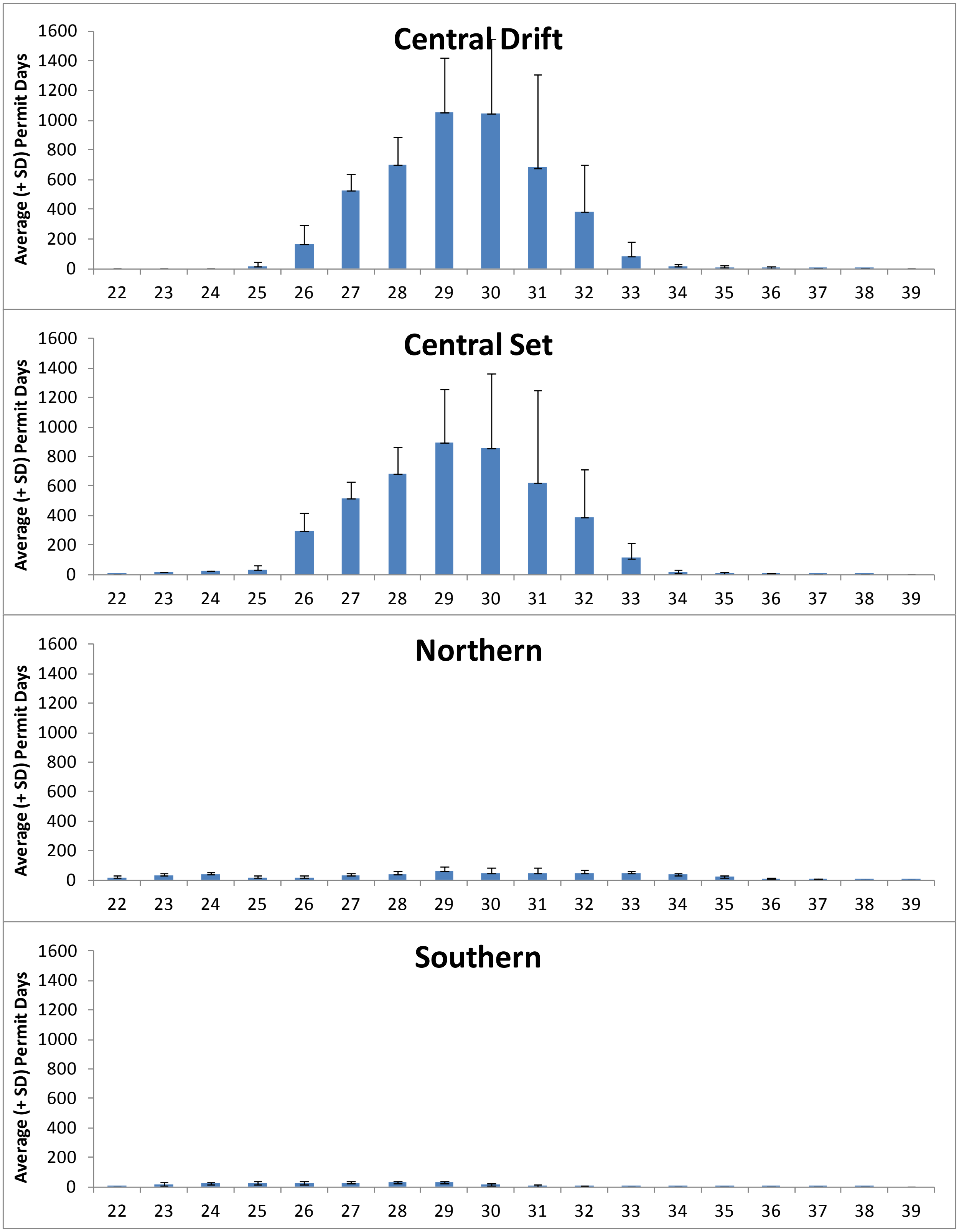

Figure 25. Seasonal distribution of fishing effort in the Cook Inlet Management Area, 2000–2010, by district, gear type and statistical week.

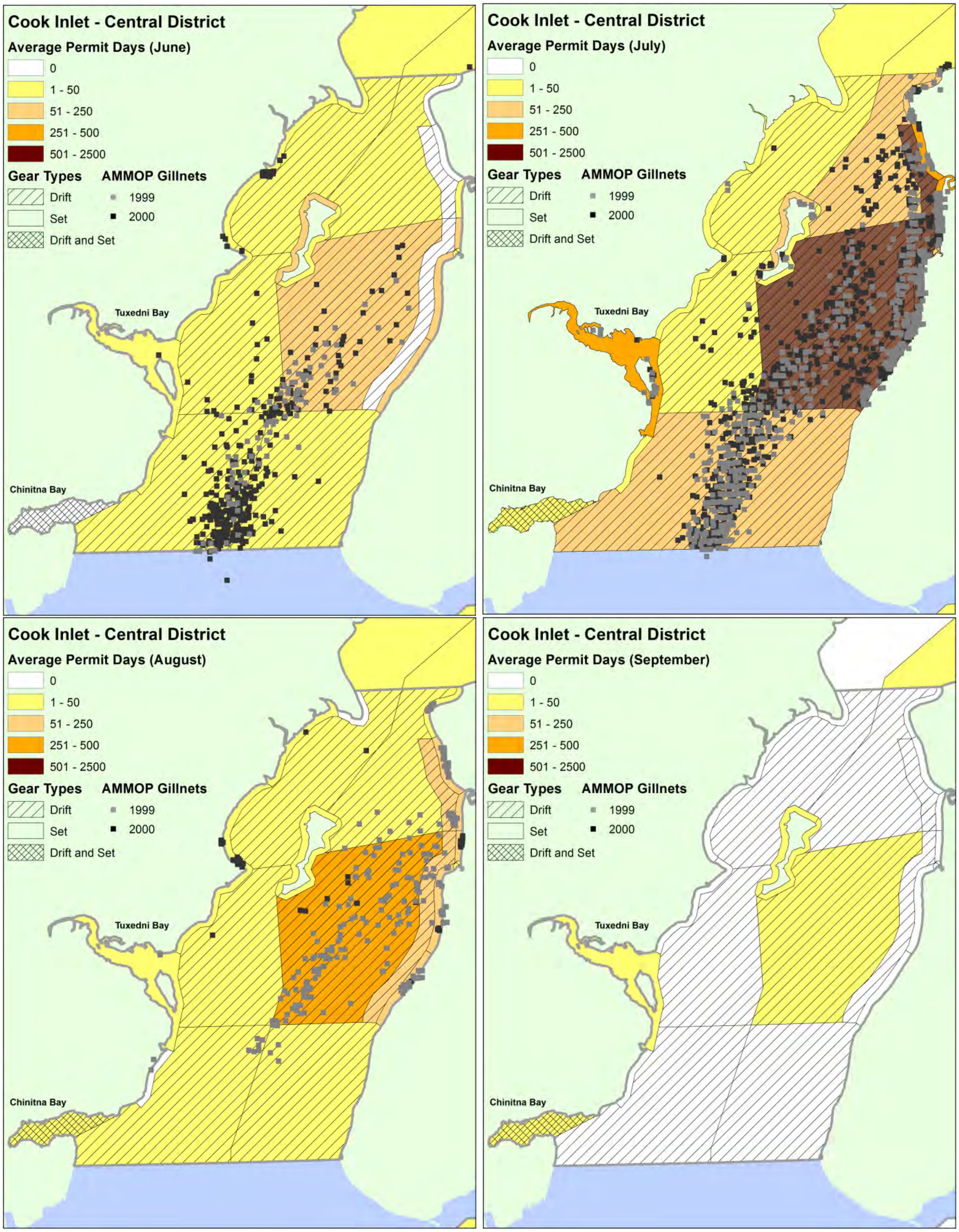

Figure 26. Monthly distribution of fishing effort and locations of gillnets sampled by the AMMOP in the Central District of the Cook Inlet Management Area.

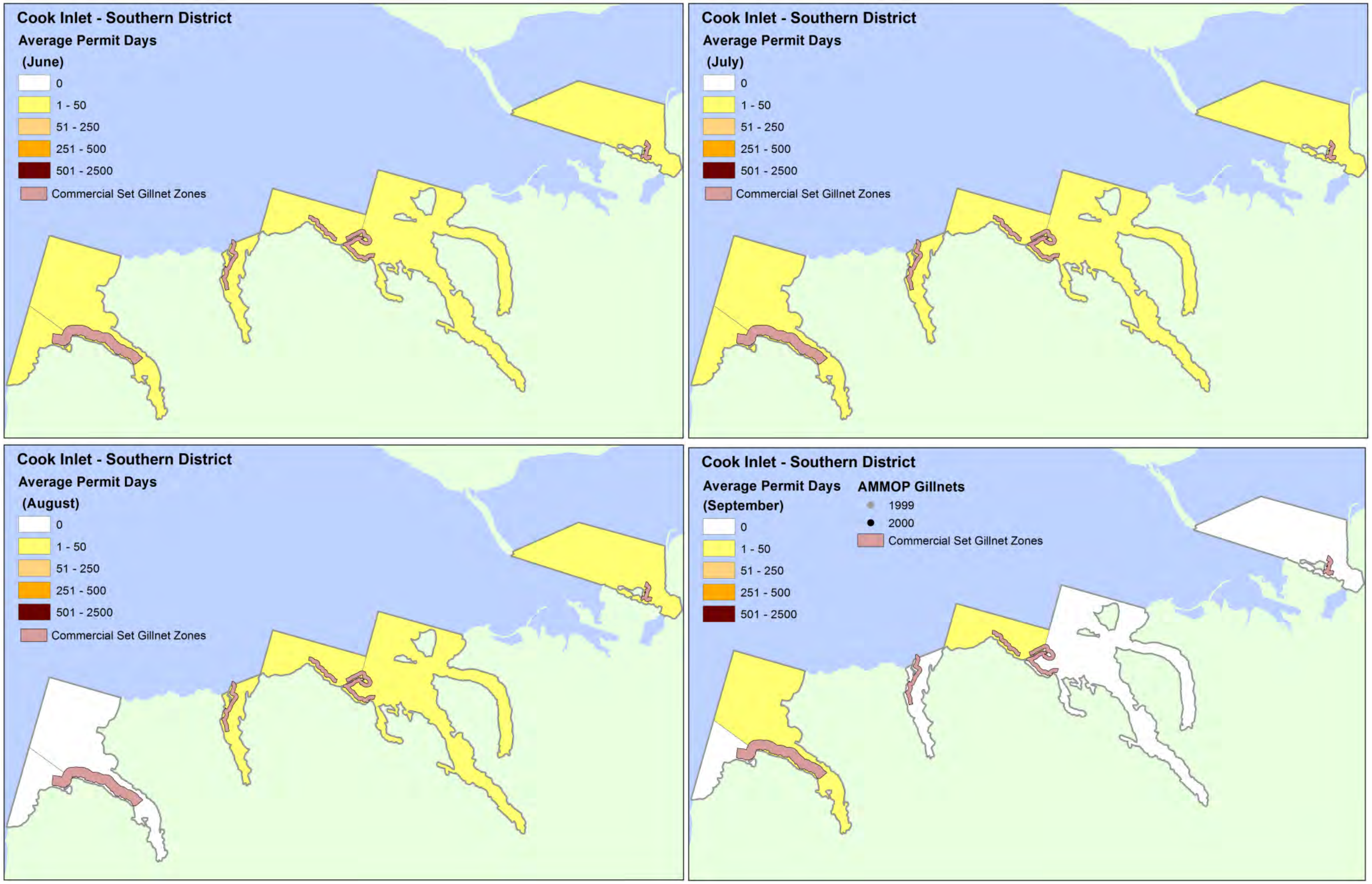

Figure 27. Monthly distribution of fishing effort in the Southern District of the Cook Inlet Management Area.

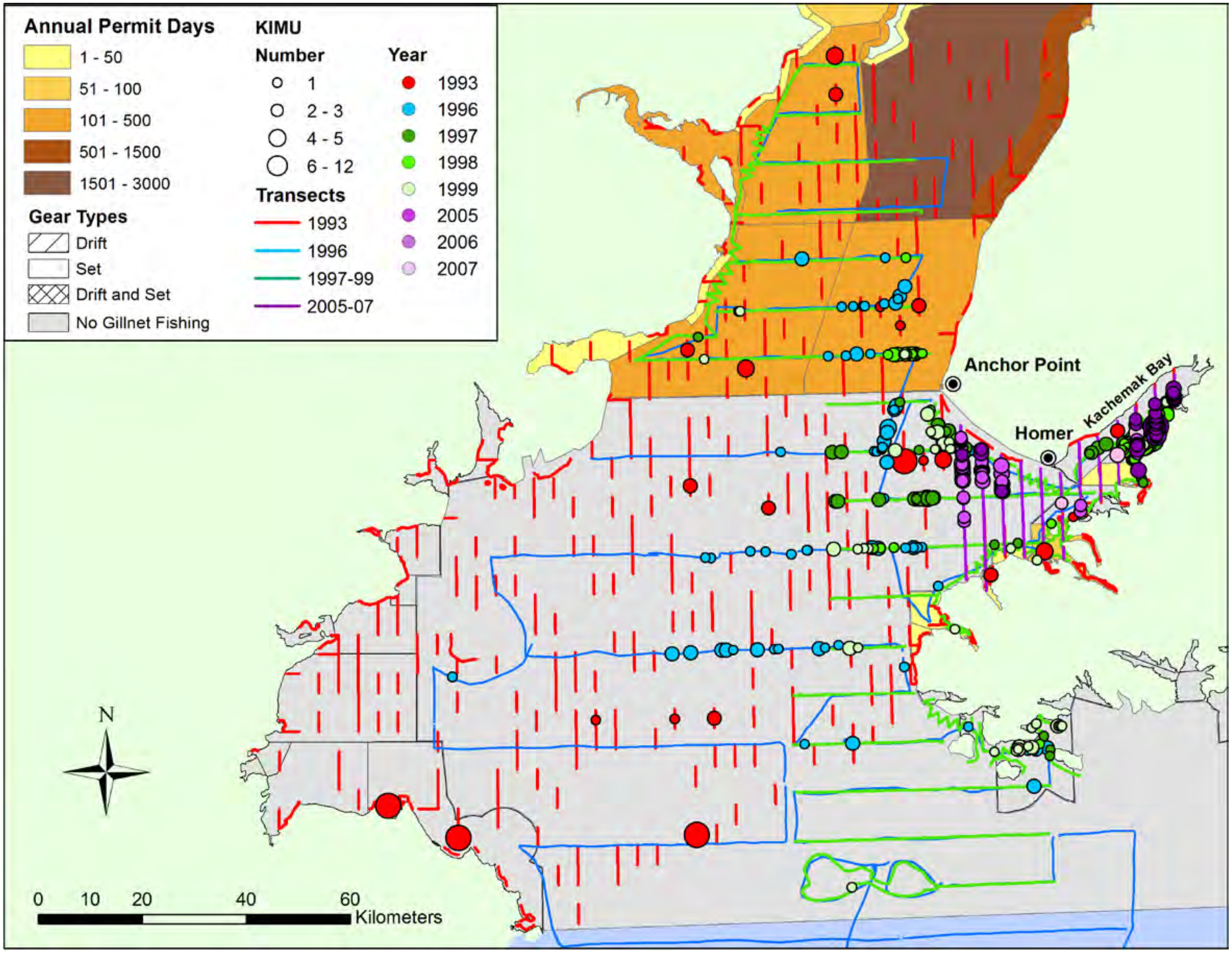

Figure 28. Locations of Kittlitz's murrelets observed during marine bird and mammal surveys of Lower Cook Inlet relative to annual fishing effort.

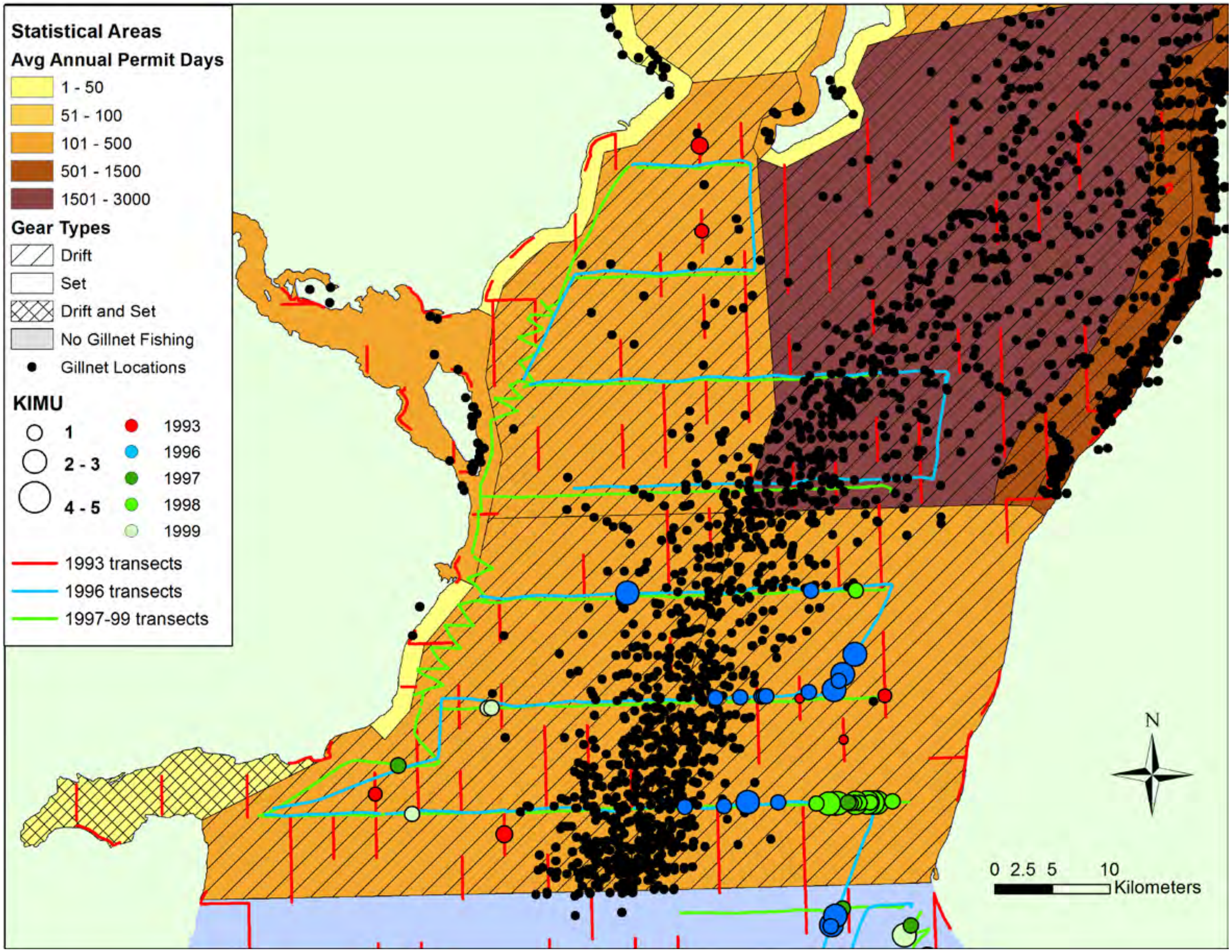

Figure 29. Locations of Kittlitz's murrelets from the 1993 and 1996–1999 surveys relative to gillnets sampled during the 1999–2000 AMMOP in the Central District of the Cook Inlet Management Area.

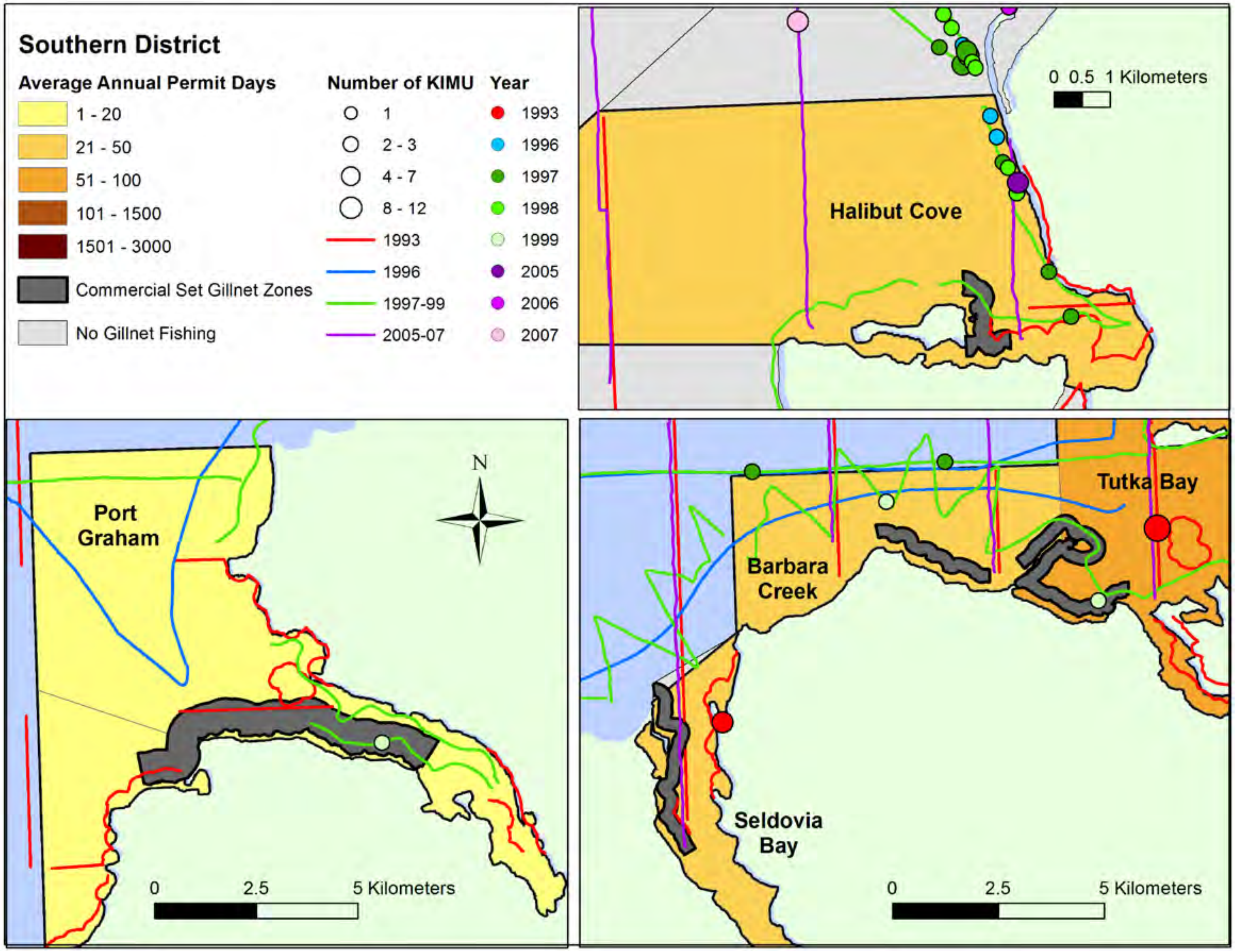

Figure 30. Locations of Kittlitz's murrelets from the 1993, 1996–1999, and 2005–2007 surveys relative to commercial set gillnet zones in the Southern District of the Cook Inlet Management Area.

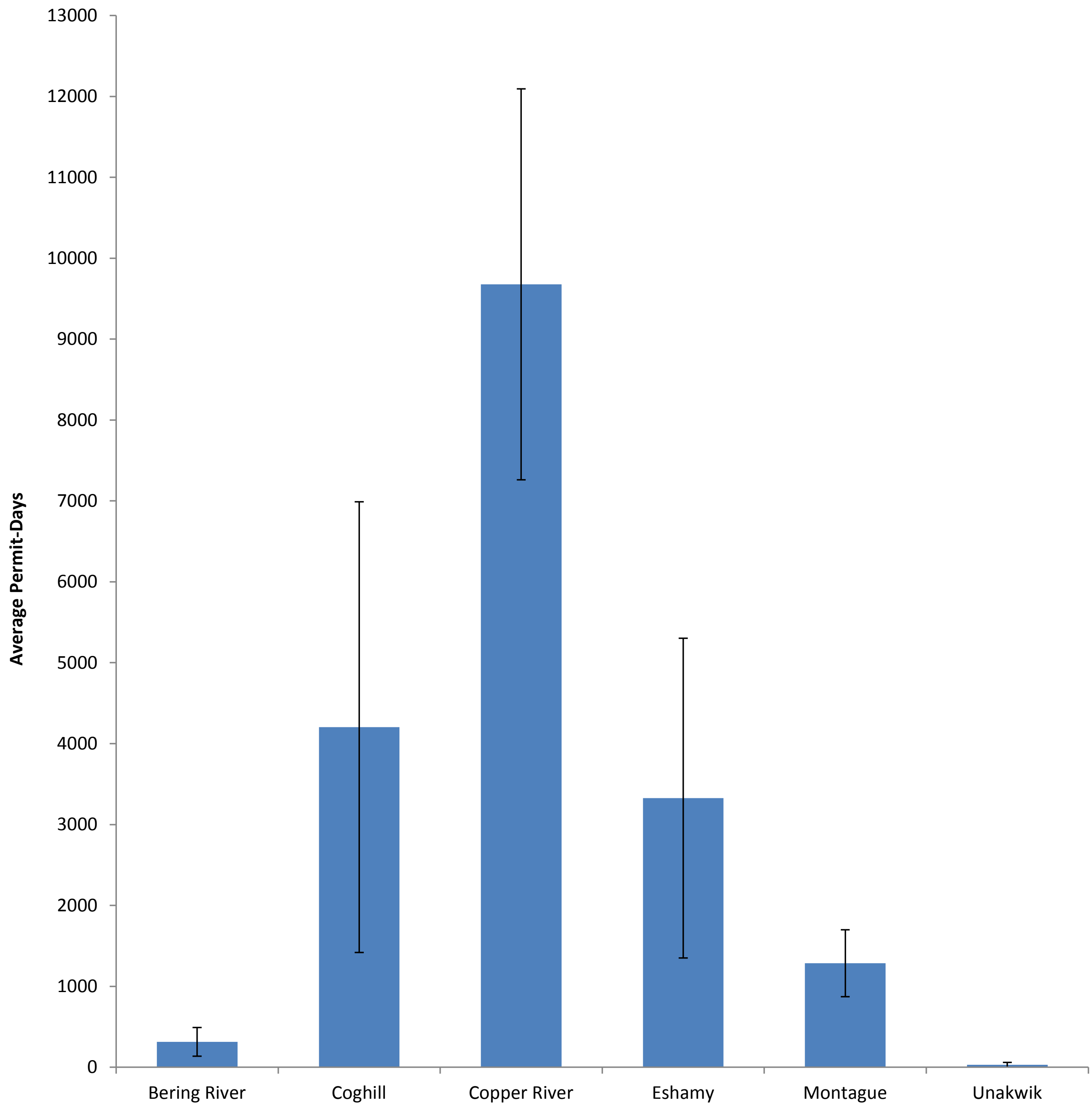

Figure 31. Annual fishing effort in the Prince William Sound Management Area, 2000–2010, by fishing district.

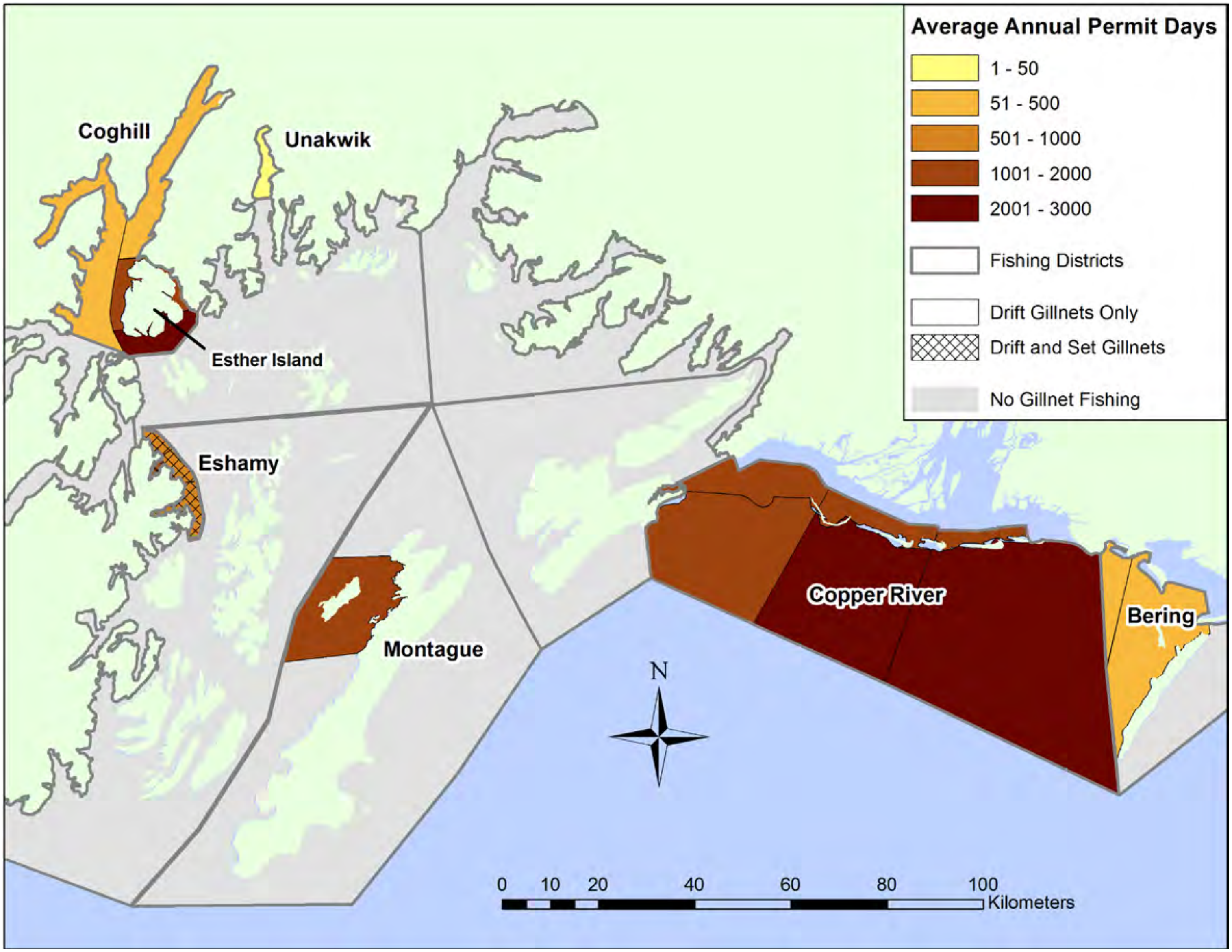

Figure 32. Distribution of annual gillnet fishing effort in the Prince William Sound Management Area, 2000–2010, by statistical reporting area.

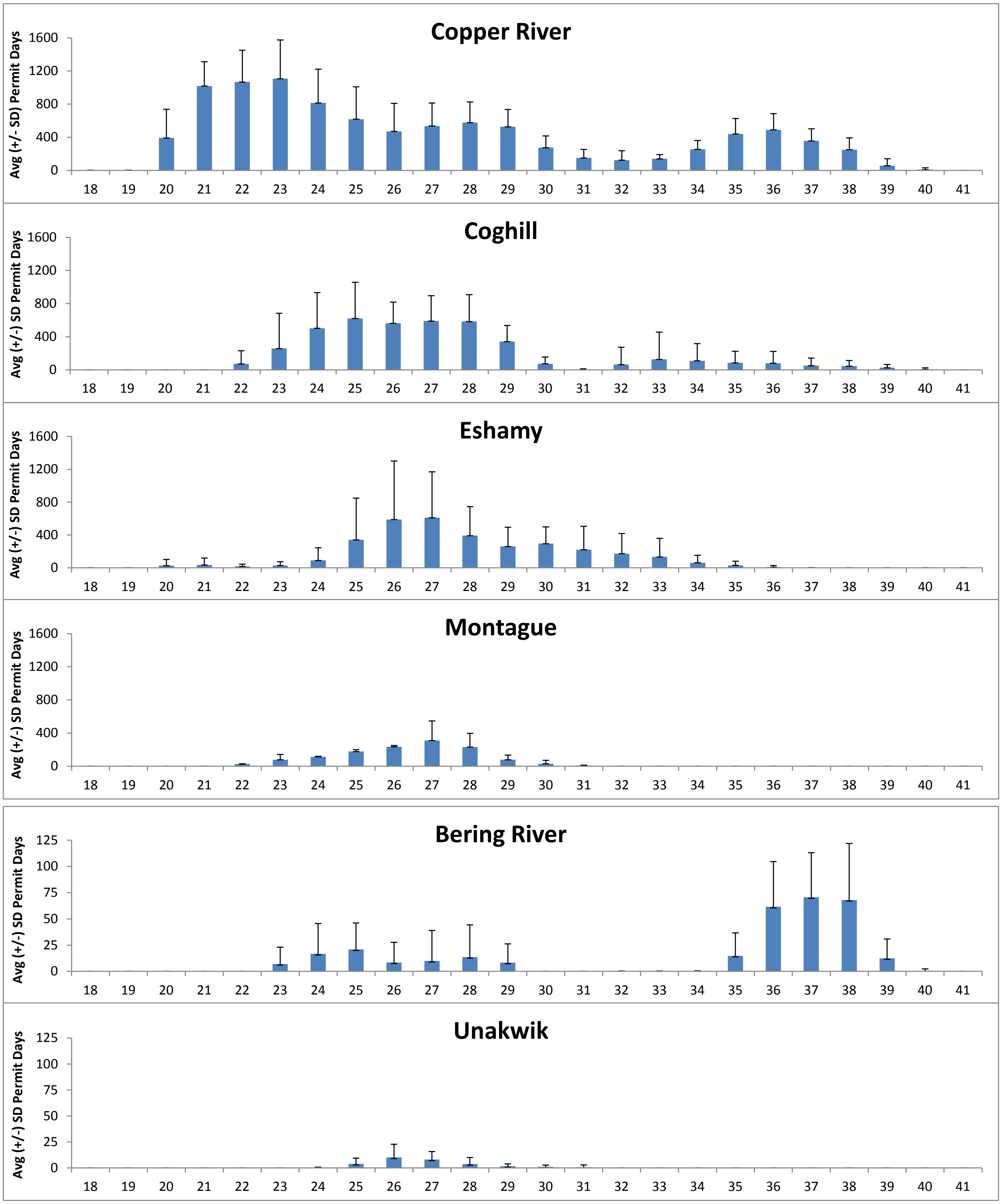

Figure 33. Seaonal distribution of fishing effort in the Prince William Sound Management Area, 2000–2010, by fishing district and statistical week. Note the different y-axis scale for the Bering and Unakwik districts.

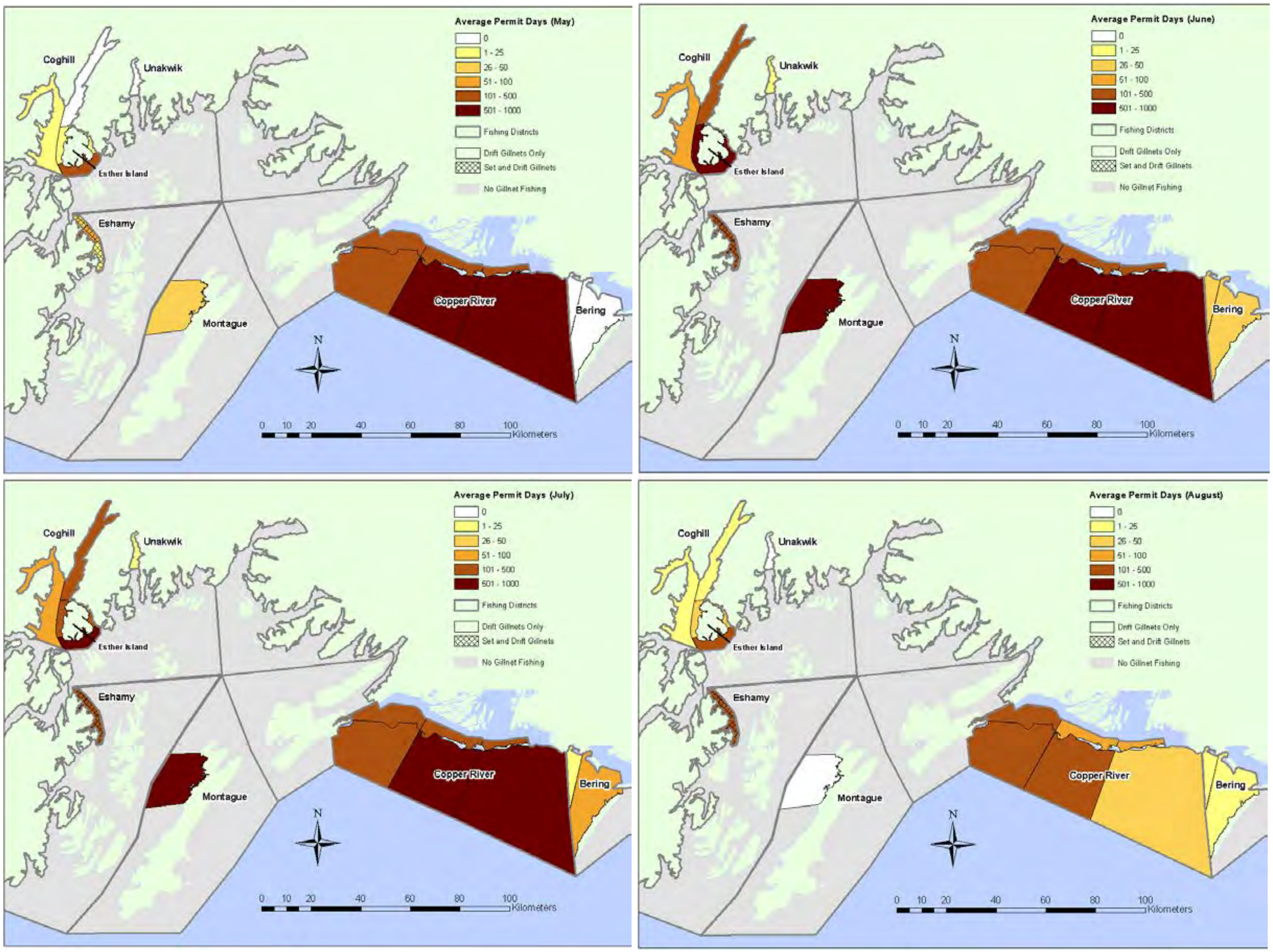

Figure 34. Seasonal distribution of fishing effort in the Prince William Sound Management Area, 2000–2010, by statistical reporting area.

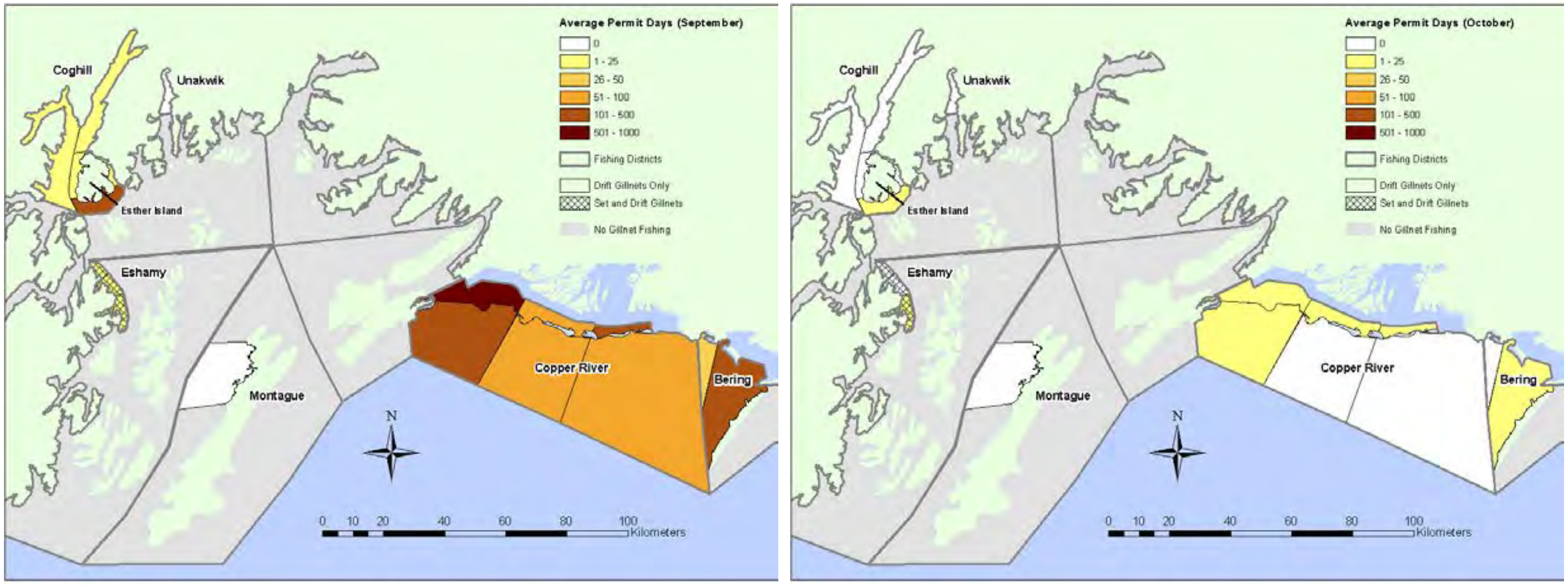

Figure 34. continued

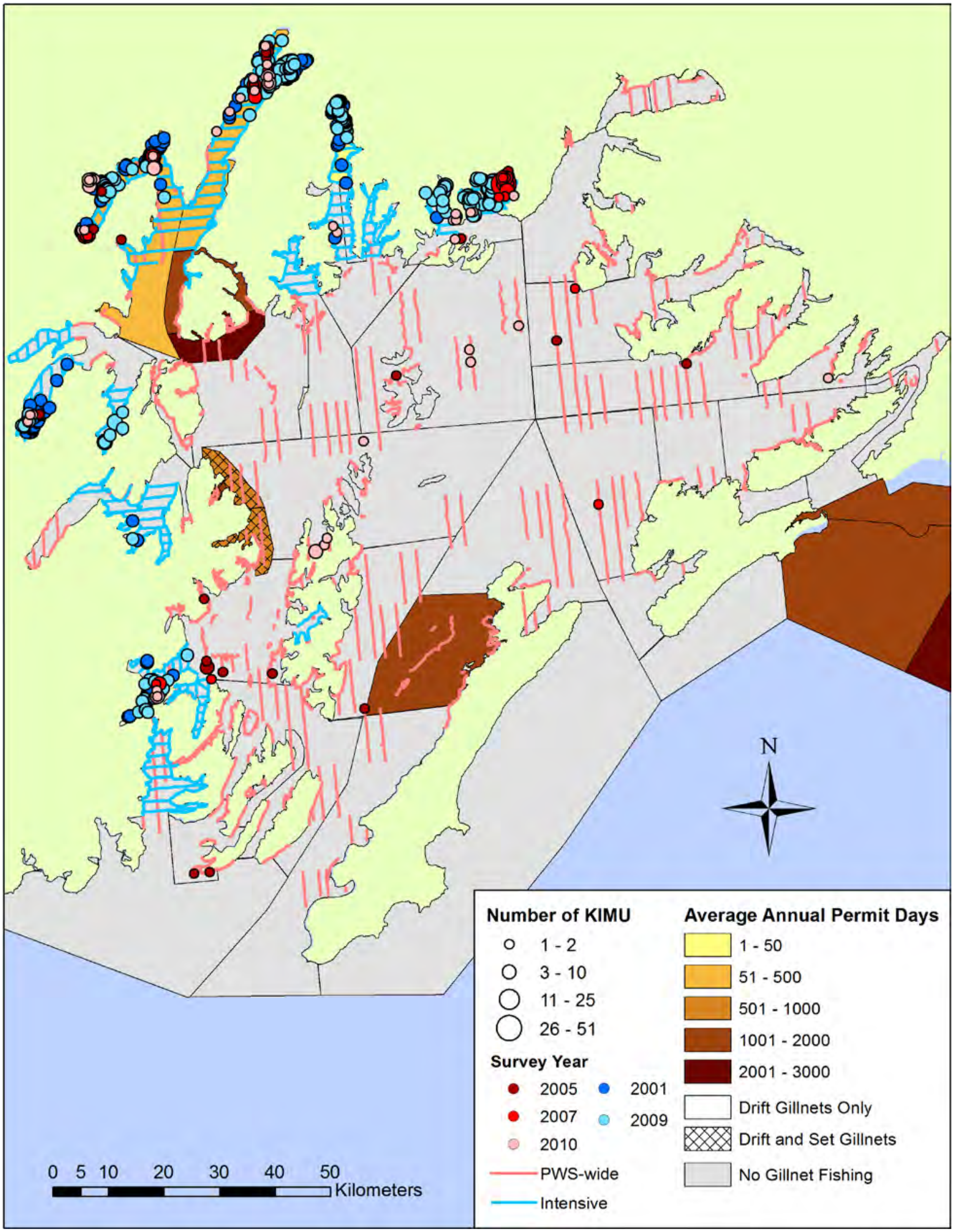

Figure 35. Locations of Kittlitz's murrelets observed during marine bird and mammal surveys of Prince William Sound relative to annual fishing effort.

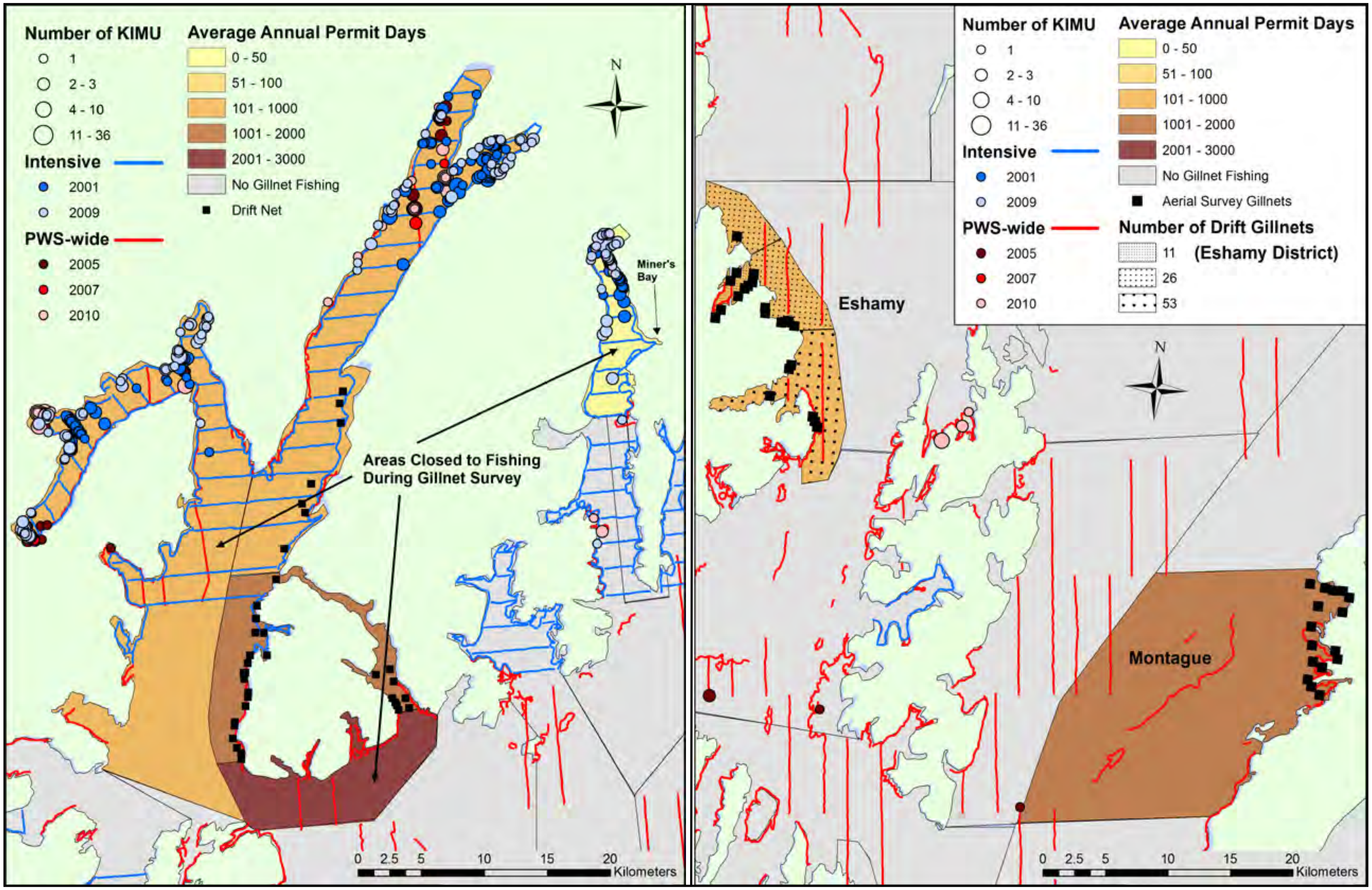

Figure 36. Locations of Kittlitz's murrelets observed during marine bird and mammal surveys of Prince William Sound relative to locations of gillnets observed during a 29 June 2009 aerial survey. In the Eshamy District (right panel) black squares indicate set gillnet locations and dot density indicates numbers of drift gillnets observed in each statistical area.

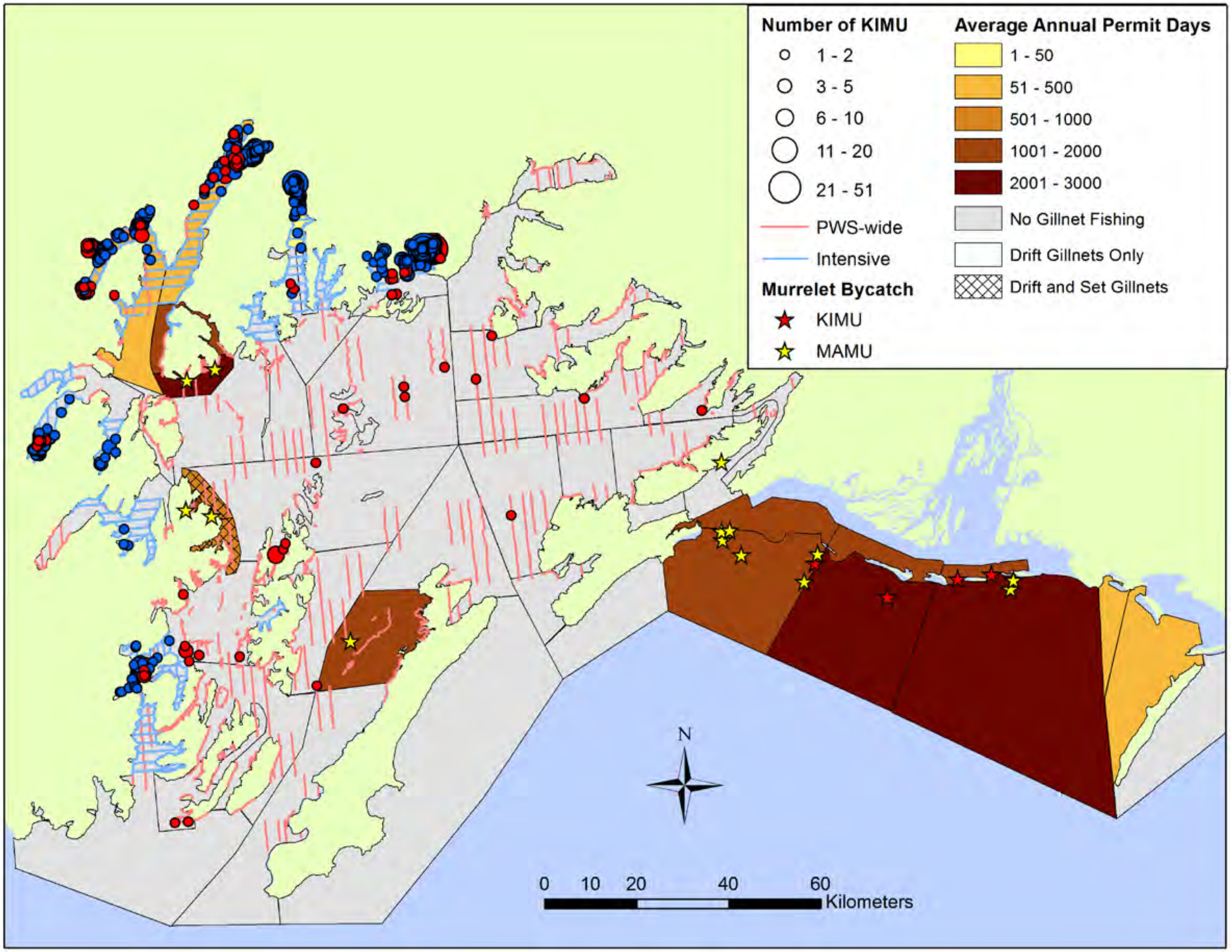

Figure 37. Kittlitz's murrelet survey locations relative to gillnet distribution and Kittlitz's and marbled murrelet bycatch locations in Prince William Sound.

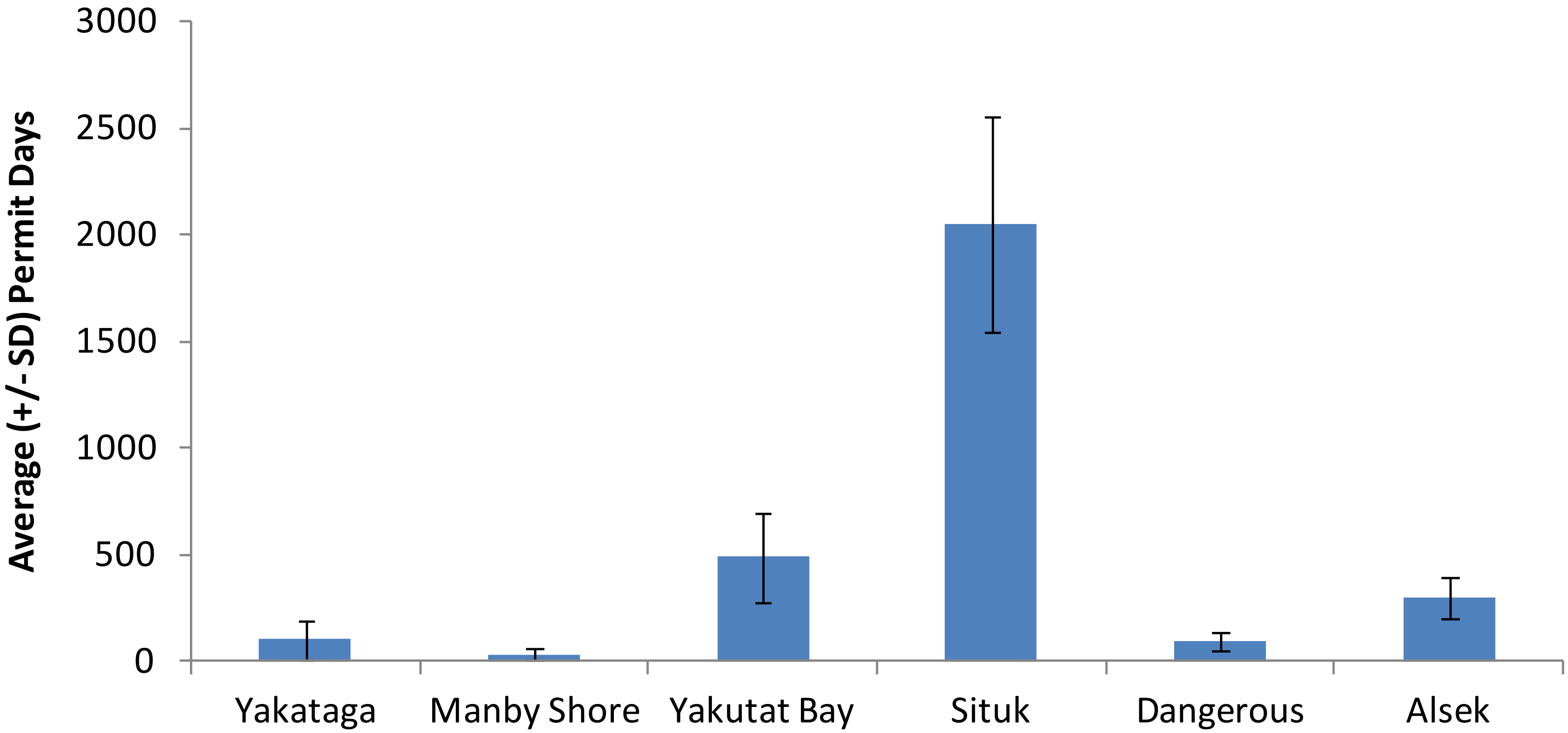

Figure 38. Annual fishing effort in the Yakutat Management Area, 2000–2010, by district, bay, or major river drainage.

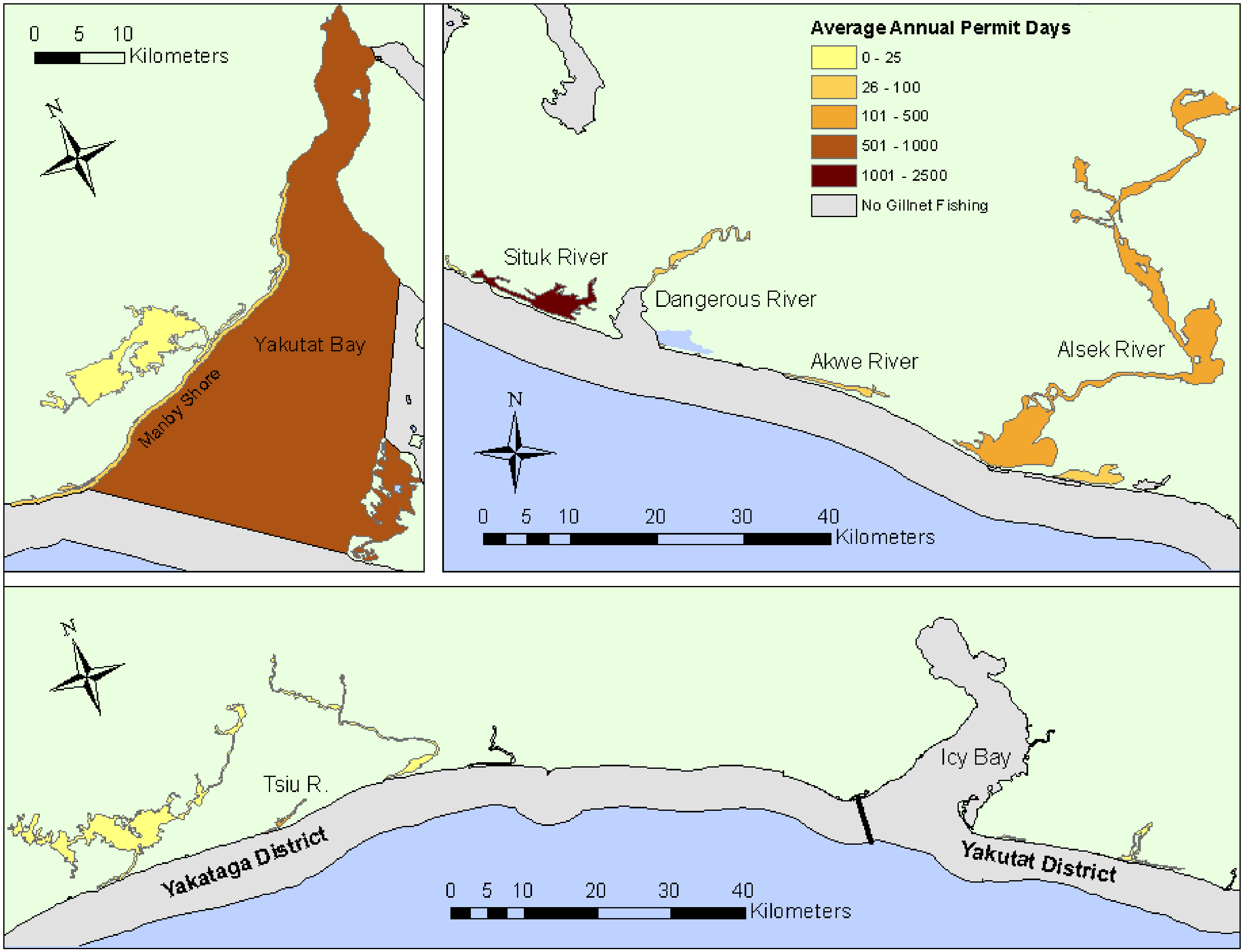

Figure 39. Distribution of annual gillnet fishing effort in the Yakutat Management Area, 2000–2010, by statistical reporting area.

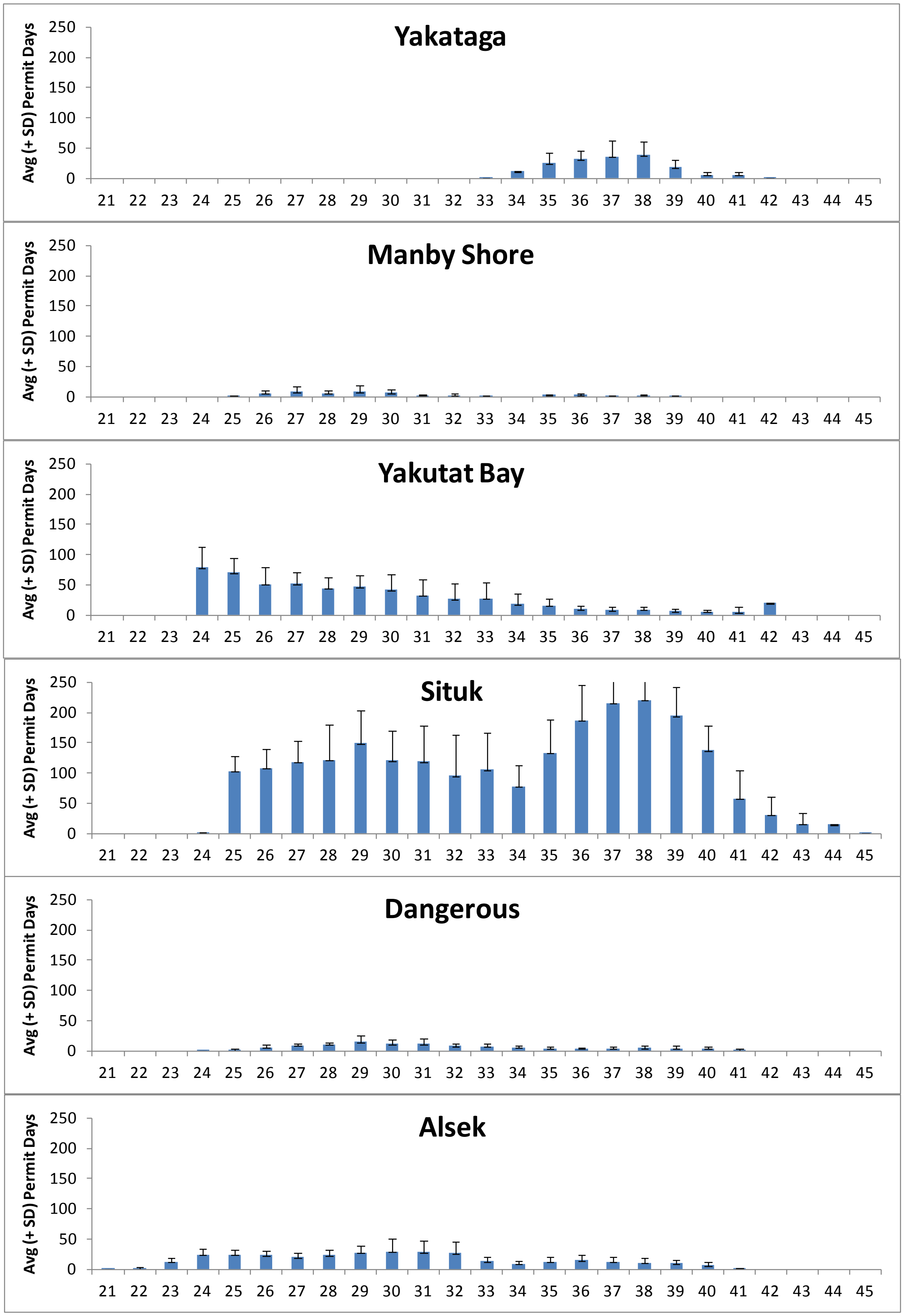

Figure 40. Seasonal distribution of fishing effort in the Yakutat Management Area, 2000–2010, by district, bay, or major river drainage and statistical week.

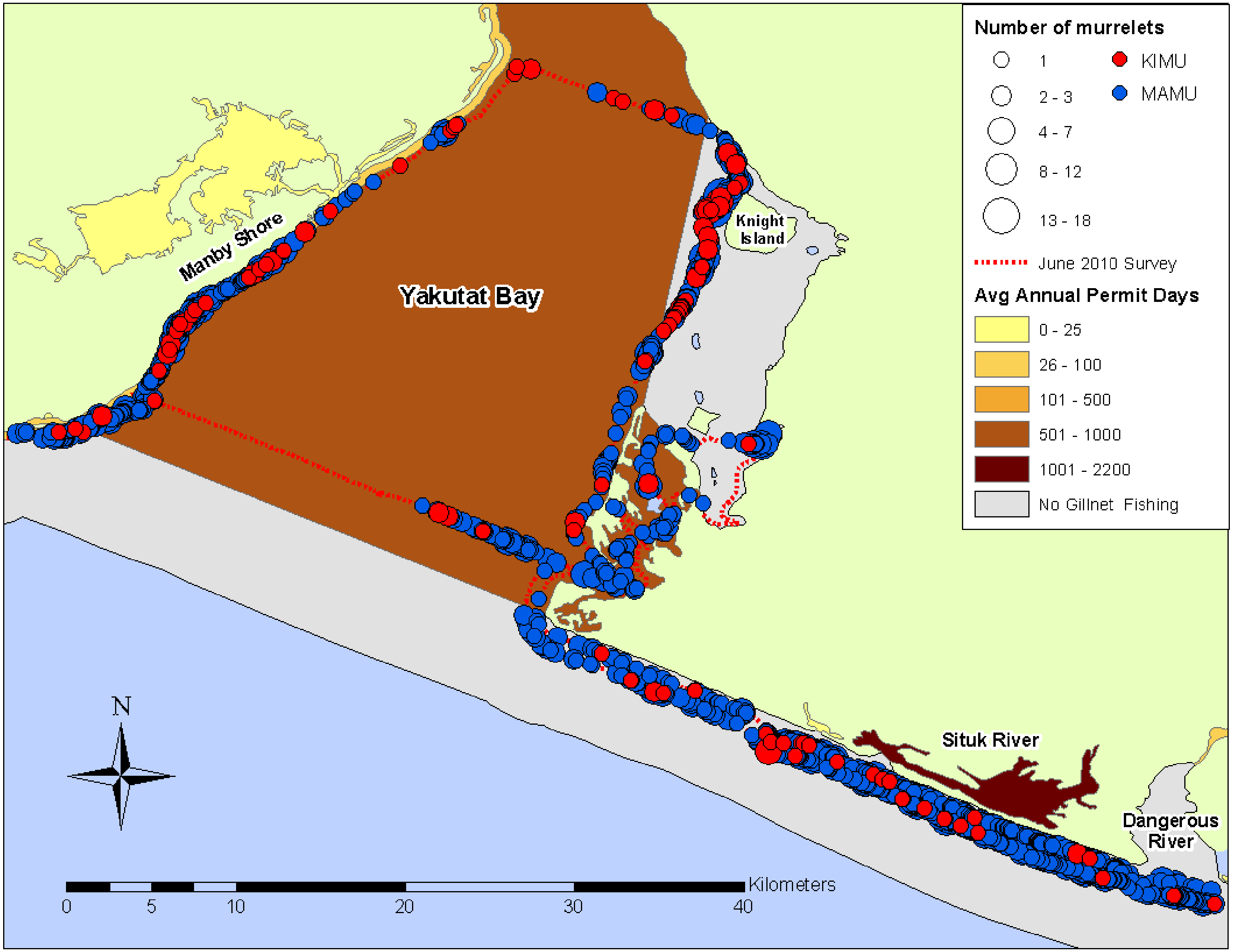

Figure 41. Locations of Kittlitz's and marbled murrelets during June 2010, survey of Yakutat Bay and the outer coast.

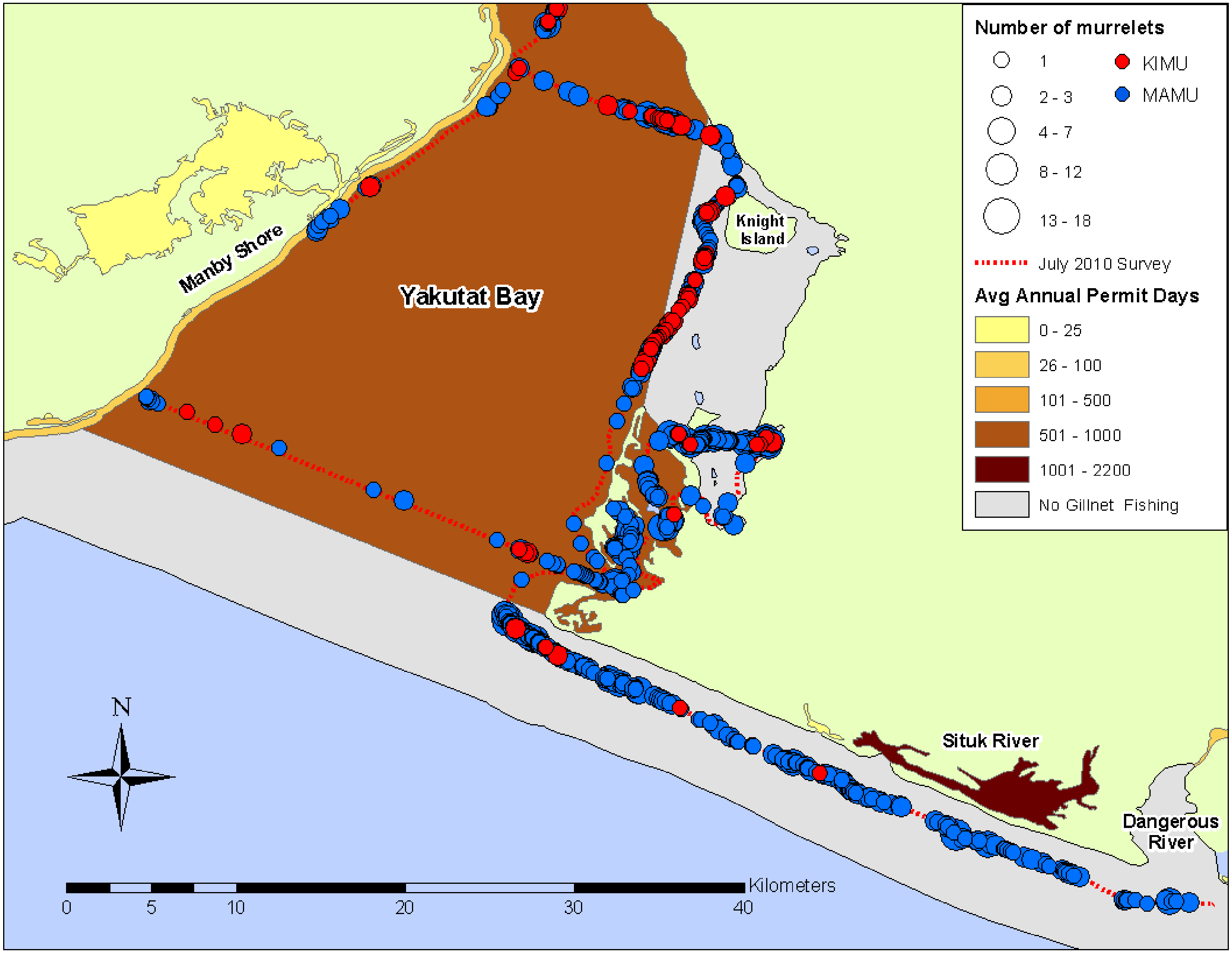

Figure 42. Locations of Kittlitz's and marbled murrelets during July 2010, survey of Yakutat Bay and the outer coast.

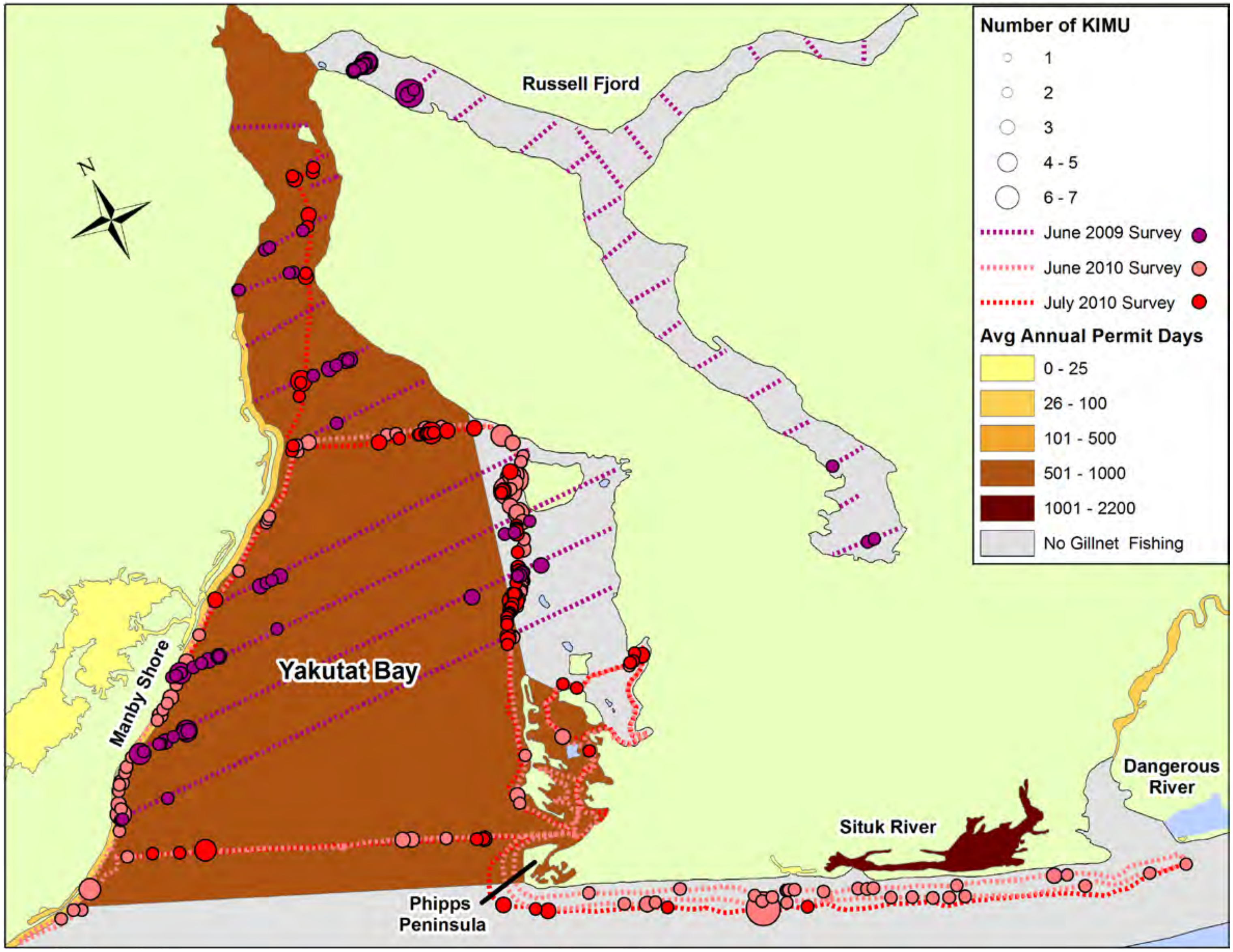

Figure 43. Locations of Kittlitz's murrelets during a June 2009 pelagic survey of Yakutat Bay and Russell Fjord, and June and July 2010 shoreline surveys of Yakutat Bay and the outer coast.

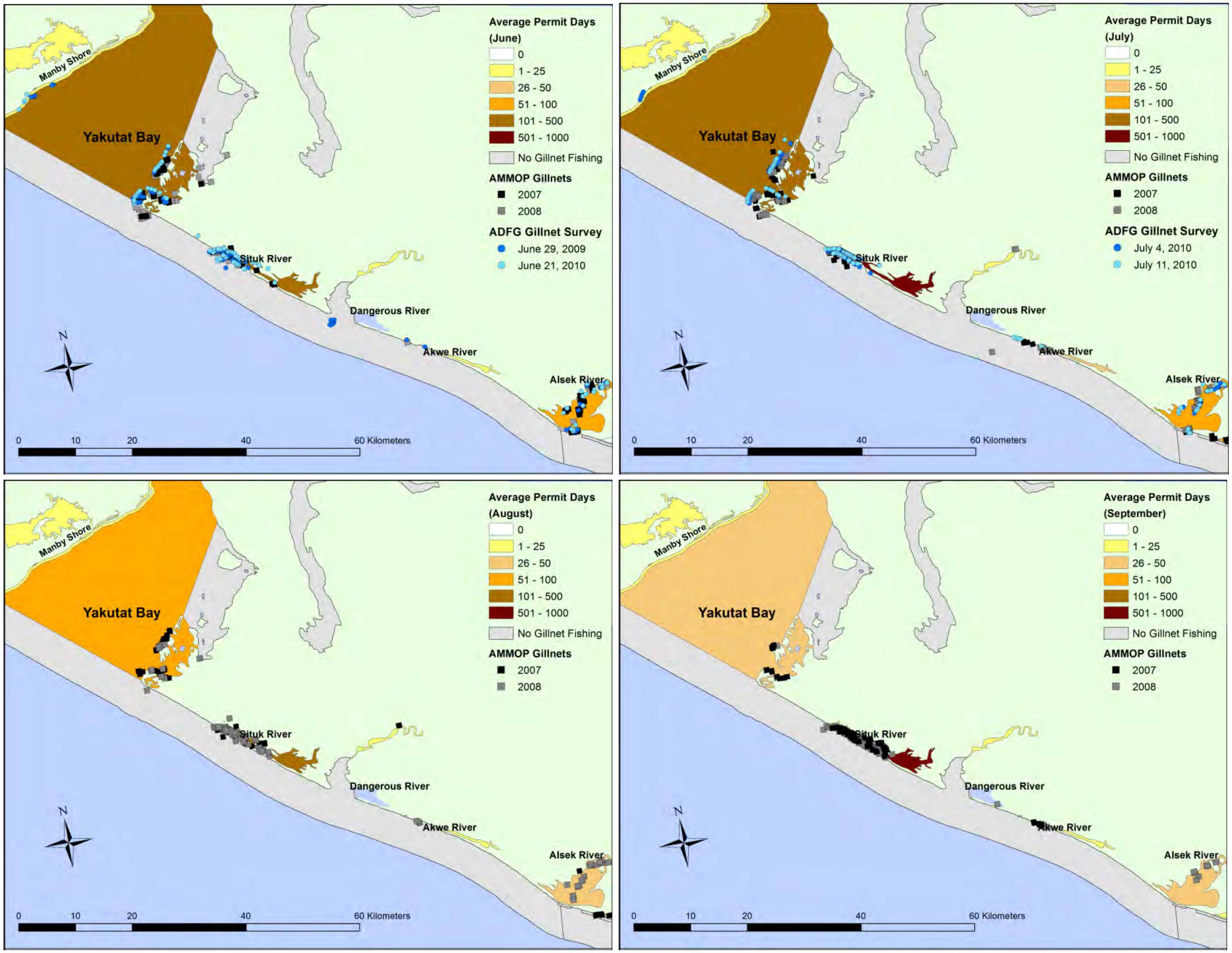

Figure 44. Monthly distribution of fishing effort and gillnets sampled by the AMMOP and observed during aerial surveys of the Yakutat Management Area.

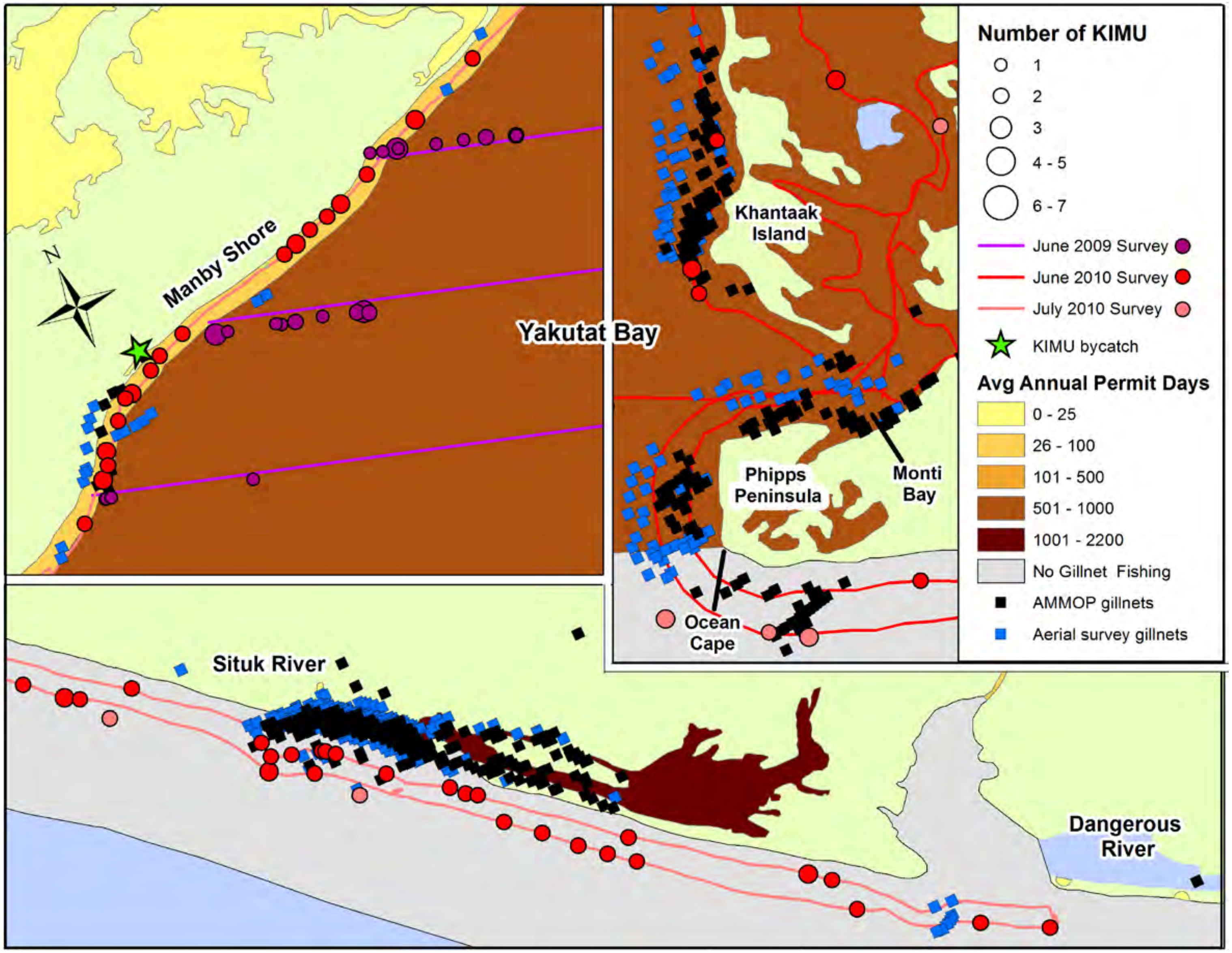

Figure 45. Kittlitz's murrelet survey locations relative to gillnet distribution and Kittlitz's murrelet bycatch in Yakutat Bay and the outer coast.

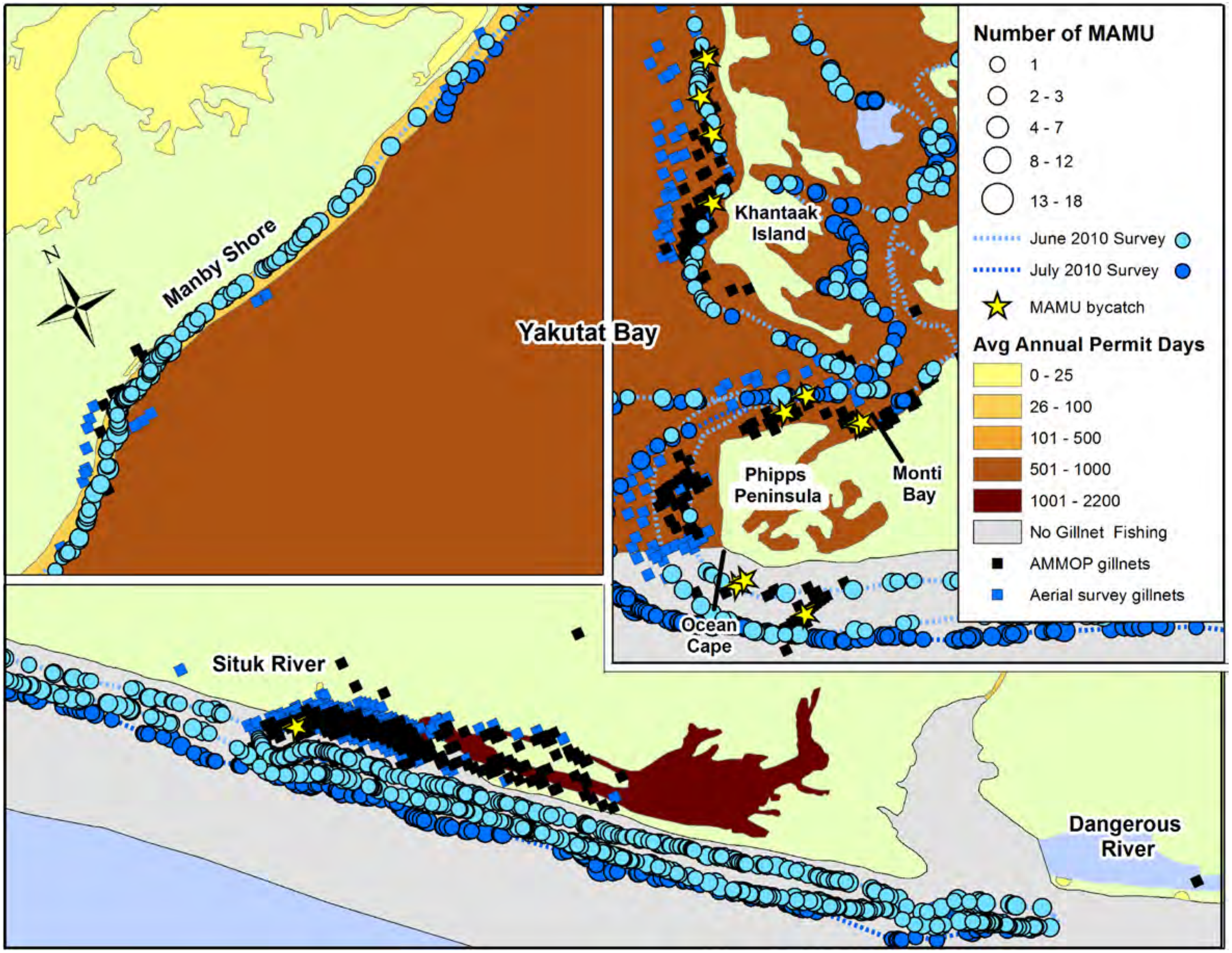

Figure 46. Marbled murrelet survey locations relative to gillnet distribution and marbled murrelet bycatch in Yakutat Bay and the outer coast.

Table 1. Statistical weeks used to calculate "monthly" averages. Range lists the weeks for which more than half the week fell during that calendar month during at least 1 year.

Month	Statistical Weeks	Range
May	18–22	18–22
June	23–26	23–27
July	27–31	27–31
August	32–35	31–36
September	36–39	36–40
October	40–44	40–44
November	45–48	44–49

Table 2. Kittlitz's murrelet survey data.

Study Area	Survey Date(s)	Coverage Area	Survey Type	Survey Purpose	Reference
Kodiak	May & August, 1994–1997	western bays	shoreline	harlequin duck surveys	Zwiefelhofer 1997
Kodiak	May & August, 1998–2000	eastern coast	shoreline	harlequin duck surveys	Zwiefelhofer 2000
Kodiak	May & August, 2001–2003	Alitak Bay	shoreline	harlequin duck surveys	Zwiefelhofer 2003
Kodiak	August, 2004–2007	western bays	shoreline	harlequin duck surveys	Zwiefelhofer 2007
Kodiak	August, 2009	west side (Kodiak NWR only)	shoreline	harlequin duck surveys	Corcoran, unpublished data
Kodiak	August, 2010	Afognak (Kodiak NWR only)	shoreline	harlequin duck surveys	Corcoran, unpublished data
Kodiak	June and August, 2011	east side and Alitak Bay	shoreline and offshore	nearshore marine bird surveys	Corcoran, unpublished data
Kodiak	1991–2008	variable	mix	various	Stenhouse et al. 2008
Cook Inlet	7–23 June 1993	Lower Cook Inlet (south of Kalgin Island)	nearshore and offshore	marine bird survey	Agler et al. 1998
Cook Inlet	14–31 July 1996	Lower Cook Inlet	nearshore and offshore	marine bird and mammal survey	Kuletz et al. 2011a
Cook Inlet	19 July–12 August 1997	Lower Cook Inlet	nearshore and offshore	marine bird and mammal survey	Kuletz et al. 2011a
Cook Inlet	21 July–12 August 1998	Lower Cook Inlet	nearshore and offshore	marine bird and mammal survey	Kuletz et al. 2011a
Cook Inlet	25 July–16 August 1997	Lower Cook Inlet	nearshore and offshore	marine bird and mammal survey	Kuletz et al. 2011a
Cook Inlet	18–26 July, 2005–2007	Kachemak Bay	offshore	marine bird and mammal survey	Kuletz et al. 2011a
PWS	July 2005, 2007	PWS-wide	shoreline and offshore	marine bird and mammal survey	Kuletz et al. 2011b
PWS	July 2010	PWS-wide	shoreline and offshore	marine bird and mammal survey	USFWS, unpublished data

Study Area	Survey Date(s)	Coverage Area	Survey Type	Survey Purpose	Reference
PWS	7 June–1 August, 2001	17 bays and fjords in PWS	shoreline and offshore	intensive survey of Kittlitz's murrelet habitat	Kuletz et al. 2011b
PWS	29 June–1 August, 2009	17 bays and fjords in PWS	shoreline and offshore	intensive survey of Kittlitz's murrelet habitat	Kuletz et al. 2011b
Yakutat	17–22 June, 2009	Yakutat Bay and Russell Fjord	pelagic	marine bird and mammal survey	Kissling et al. 2011
Yakutat	21–22 June, 2010	Yakutat Bay and outer coast	shoreline and pelagic	murrelet survey	ADF&G, unpublished data
Yakutat	5–13 July, 2010	Yakutat Bay and outer coast	shoreline and pelagic	murrelet survey	ADF&G, unpublished data

Table 3. Number of permit holders that reported catching fish (Reported) and the number of set gillnets observed fishing (Observed) during aerial surveys of gillnet distribution in the Yakutat District.

	6/29/2009		6/20/2010		7/4/2010		7/11/2010	
Area	Reported	Observed	Reported	Observed	Reported	Observed	Reported	Observed
Alsek	12	20	8	24	7	22	5	22
Dangerous	0	8	0	0	2	0	0	0
Yakutat Bay	21	27	2	22	12	17	19	24
Situk	37	36	44	54	46	46	43	35
Akwe	1	2	0	0	2	1	0	6
Manby Shores	5	6	1	4	1	4	0	1
Total	76	99	55	104	70	90	67	88
% Reported		77%		53%		78%		76%

Table 4. Number of permit holders that reported catching fish (Reported) and the number of set or drift gillnets observed fishing (Observed) during an aerial survey of gillnet distribution in Prince William Sound conducted on 29 June 2009.

Gear Type	District	Area	Reported	Observed	% Reported	% Observed
Drift	Coghill	College Fjord	17	7		41%
Drift		Granite Bay	48	33		69%
Drift	Eshamy	Lighthouse	48	49		102%
Drift		Main Bay	11	11		100%
Drift		Falls Bay	33	35		106%
Drift		Eshamy Bay & Pt. Nowell	89	53		60%
Drift	Montague	Montague	50	19		38%
Set	Eshamy	Lighthouse	1	2	50%	
Set		Main Bay	11	21	52%	
Set		Falls Bay	6	16	38%	
Set		Eshamy Bay & Pt. Nowell	6	8	75%	

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Appendix A

Carter-Isleib Correspondence in 1982 related to Gill-Net Mortality of *Brachyramphus* murrelets in Alaska

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In 1994, Harry Carter and Mike McAllister prepared a draft manuscript on gill-net mortality of Marbled Murrelets (*Brachyramphus marmoratus*) in North America that was later published as Chapter 27 in "Ecology and conservation of the Marbled Murrelet" (Carter et al. 1995). In this draft manuscript, Carter had included a long section of raw 1982 correspondence between Carter and the late Pete Isleib (deceased in 1993) about Isleib's Alaska observations of gill-net mortality of both Marbled Murrelets and Kittlitz's Murrelets (*B. brevirostris*) in the 1970s and early 1980s. In 1982, Carter had been a M.Sc. graduate student at the University of Manitoba (under the supervision of Spencer Sealy), was preparing a paper on gill-net mortality of Marbled Murrelets in Barkley Sound, British Columbia (Carter and Sealy 1984), and was very interested in obtaining detailed unpublished information on gill-net mortality from Alaska. With a near lack of historical information about historical gill-net mortality of Marbled Murrelets in Alaska in the literature, Carter felt that details provided by Isleib should be made fully available and preserved in the literature. However, the reviewers and editors did not see the value of including this raw correspondence and they requested a summary instead. A summary was provided in the published paper under the subtitle "Historical records of mortality: 1950s to 1980s" (Carter et al. 1995:272).

On 26 February 2012, Carter was contacted by Karen Blejwas (Alaska Department of Fish and Game, Juneau, Alaska) who requested a copy of the 1982 Isleib letter for her use in assessing potential impacts of gill-net mortality on Kittlitz's Murrelets in Alaska. Carter searched for the original copy of the Isleib letter but did not find it in its original location and suspected that it may have been lost. However, he was able to find an electronic copy of the 1994 draft manuscript which contained the section with raw 1982 correspondence between Carter and Isleib. With the immediate need for this information for assessing Kittlitz's Murrelet impacts, Carter provided a copy of this manuscript section below (complete with a few Isleib spelling errors and formatting from the original letter) which provided the basis for the published summary in Carter et al. (1995), as well as certain information provided in Carter and Sealy (1984) and Sealy and Carter (1984):

"In the 1970's, the only documentation of mortality of murrelets in gill nets in Alaska has been provided by M.E. "Pete" Isleib. Isleib was a famous fisherman-ornithologist that was very familiar with the Marbled Murrelet and other seabirds throughout much of Alaska (e.g. Isleib and Kessel 1973). Isleib was also a gill-net fisherman and as such was intimately familiar with seabird mortality during gill-net fishing. Carter and Sealy (1984), Sealy and Carter (1984), and DeGange et al. (1993) have previously reported some of Isleib's observations or comments but his extensive knowledge has not and will never be fully reported due to his untimely death in 1993. However, after attending the January 1982 symposium on "Seabird-commercial fisheries interactions" held by the Pacific Seabird Group in Seattle, Washington, Isleib (MEI) and Carter (HRC) corresponded about gill-net mortality in Alaska. In a letter, Isleib provided a wealth of information about the nature and extent of murrelet mortality in Alaska during the 1970's and perhaps earlier. Due to the great significance of his observations, we have included the following excerpts verbatim from Isleib's correspondence, dated 25 February 1982, where he answered many of Carter's questions (posed in a letter dated 14 January 1982) about gill-net mortality:

MEI: In the following, I shall be specifically referring to your questions concerning Marbled Murrelet mortality. Unless otherwise stated all data will refer to Statistical Area E; Prince William Sound/Copper-Bering River Districts. Specific districts and periods which openings occur by gear type: Copper River District, mid May to late September, drift gillnets only; Bering River District, mid June to late September, drift gillnets only; Coghill-Unakwik District, 3rd week in June to early August, drift gillnets only; Eshamy District, late June to late Aug (open 1 in 5 years ave.), set nets and drift nets. There are approx. 500 driftnet permits and about 15 setnet permits. Your questions: Murrelet Mortality.

HRC: How many murrelets are killed? - Per boat, per day, per week, per fishing season?

MEI: My best guestimate for the degree of magnitude for all of Area E districts is several hundreds annually. The numbers have increased in the past 20 years due to several factors - the vessels are continuously fishing around the clock (including night hours) and the use of finer web and that more units of gear are actively fishing - not sitting in port during an open period.

HRC: When are murrelets killed? - What time of year (e.g. late June-late July)? - What time of day (night or day)?

MEI: Through-out the fishing season. Most are killed at night, 80%+.

HRC: Where are murrelets killed? - Bristol Bay, Prince William Sound, Cook Inlet, Kodiak I.? - In "shallow" water, channels, mid-sound? - Exact localities would be most useful.

MEI: (Other statistical areas I'll discuss later). In the Copper & Bering River Districts murrelets are not numerous except during brief migrational periods in early September and most birds occur offshore. These districts front the open Gulf of Alaska. In these districts most murrelets are caught between 1/2 and 3 miles offshore. Water depth at 3 miles offshore is about the 10 fathom line. The Copper R. has 20 times the silt load of the Mississippi R. and on the delta and nearshore, murrelets are uncommon. My best guestimate on the murrelet mortality in these districts is from <u>1 to 3 hundreds annually</u>. A similar or slightly higher (2 to 500) mortality of Common Murres occurs here.

In the Coghill-Unakwik and Eshamy districts murrelets are numerous. These districts are either within or at the mouths of fiords. The fiords are very deep, exceeding 100 fathoms, the water is fairly clear at the fiord mouths but milky with glacier flour in the heads. These districts host approx: 10,000+ Kittlitz's Murrelets, 100,000+ Marbled Murrelets, 2500+/- Pigeon Guillemots, 100+/- each of Common Murre, Tufted and Horned Puffins and very small numbers of Parakeet and Rhinoceros Auklets.

Marbled Murrelets are the most numerous species and occur as pairs, singles and small loose knit groups of up to 50 birds in a small area. They are wide spread in all of the district's waters. Killed annually 500+/-.

Kittlitz's Murrelet is numerous in the very heads of the fiords amid the drifting bergs and bits of brash ice of the glaciers. These areas are beyond the locations of fish concentrations and fishing boats - so conflicts and bird mortalities are minimized. The relatively few birds present in the fishing fleet appear to have a greater net avoidance capability than Marbled Murrelets.

Pigeon Guillemot while breeding as scattered pairs throughout the shoreline areas are not known to be caught and must have a high net avoidance capability.

A few small colonies of both puffins occur in or within 20 miles of the district's waters and they also are not reported caught and must have an avoidance capability.

There are no Common Murre colonies closer than 50 miles of these districts. But small groups of non-breeding wandering birds are found in the more open water (away from shoreline) areas of these districts and in relation to their abundance (1000+/-) they are frequently caught. My guestimate is 100+/-per annum mortality.

Now I promised some statewide views and estimates of mortalities in other salmon Statistical areas.

<u>Southeastern Alaska</u> is similar to B.C. Canada and the Prince William Sound Fiord Districts. Inside waters from Dixon entrance to Lynn Canal (Driftnet only). I have no first hand knowledge but suspect Murrelet & Murre mortalities in similar form as Prince William Sound.

Yakutat District of S.E. Alaska is a setnet only area. Alcid mortality is probably very low and restricted to the small area in Yakutat Bay.

Cook Inlet area both drift & setnets are used. Due to bird distribution and locations of specific fisheries I suspect the highest mortalities of murrelets in the setnet regions of southern Cook Inlet where murrelets are frequent. And due to the offshore tendency of Murres that there is some murre mortality in the southern reaches of the drift fishery in the central inlet.

Kodiak Area set net only - I have no data.

Chignik Area no drift or setnets in region. I have no data.

Aleutian Islands Area no drift or setnets in region. I have no data.

Alaska Peninsula Area both drift and set nets allowed. I suspect some fairly significant Murre mortalities but it is beyond the range of murrelet abundance. Small alcids including Marbled Murrelets occur. I have no first or second hand data from this area.

Bristol Bay area murrelets are very rare in this area. Murres do occur and I believe up to several hundreds may be killed annually and most notably in the Togiak district. I have fished Bristol Bay for the past 3 years and the only birds I've killed were 3 Common Murres, all in the Togiak District in 1981 while fishing at night.

Kuskokwim Area, Yukon Area, Norton Sound-Port Clarence Area, Kotzebue-Northern Area setnet only. I have no data for these areas."

HRC: What depth are they caught at? - Shallow, deep, 20 m or 5 m?

MEI: if you are questioning what depth in the net - varying depths in the nets from the surface to 10 meters mostly 3 to 5 meters down. Depth of net beyond 60 meshes deep does not appear to be an increased mortality factor.

HRC: Are birds killed in the same area every week or year? - Are they killed throughout the fishing season?

MEI: Murrelets are captured in the same locations year after year - throughout the season's extent. Young of the year - first noted in mid-July are more often noted among those killed than adults in proportion to their respective numbers in the areas.

HRC: What other alcids are killed in the same areas and times as Marbled Murrelets? - Species, general numbers, more or less than murrelets?

MEI: Answered.

HRC: How do the birds "act" when near nets? - Do they swim along the net, dive by the net, in small flock sizes (say 1-2 birds), feed on "stuff" that has accumulated on nets, appear to dive under nets?

MEI: Marbled Murrelets will feed in the proximity to nets as well as else where but appear to be displaced by a vessel or activity aboard a vessel. Young of the year show little fear of vessels. The attention of the birds is keyed to the presence or absence of small fishes. If small feed fishes are present along or near nets murrelet are easily displaced 500 to 1000 feet of the vessel if there is a commotion on the vessel - returning if all activity ceases.

Small fishes may be blocked temporarily by the "wall" effect of the net - reluctant to go through the net's webbing for a period of time. Small or large balls of 1000's of small fishes are commonly observed daily in the Prince William Sound fiord districts. In some areas and seasons, plankton build-up on the webbing is of substantial volume, especially in the Prince William Sound fiord districts. The individual strands of web appear several times their uncoated size "an added wall effect". This undoubtedly must attract small fishes to some extent.

The murrelets usually in singles or pairs swim along the nets, frequently diving, often surfacing on one side and then the other. This occurs with nets 120 meshes deep (60 feet) with mesh sizes of 5 1/2 inches. They may actually be going through these nets, I cannot tell. But as I have said 80+ percent of the birds are caught at night.

HRC: Are birds caught when they are disturbed by a passing boat or do they dive and get caught while boats are still between net resets?

MEI: I do not believe murrelets are caught in reaction to surface disturbances. They are more than likely caught while in the act of pursuing small feed fishes. This may not be the case for some of the "young of year" mortalities. Young of the year tend to dive from suspected danger on the surface while adults tend to fly.

Murres, on the other hand, tend to dive from surface dangers and disturbances more frequently than murrelets.

HRC: What is the fishing season? - Does it operate on an opening system such that fishing occurs only 3-4(/) days/week? How long and deep are nets set, what type of net (e.g. Sockeye - 10-13 cm mesh size, multi- or mono-filament nylon)? - Do more boats fish at day than at night?

MEI: As covered earlier in the general preamble [not included in these excerpts]. In the Copper River-Bering River Districts and P.W.S. districts <u>as a general rule</u> fishing periods are 3 to 4 days per week. daylight sets tend to be 1 to 3 hours while night sets are longer 3 to 6 or 8 hours. More boats fish by day than at night on the Copper-Bering Systems but a more overriding factor is the tides. The boats tend to fish harder in the low tide and flood tide and less at high tide and ebb tide.

In the PWS fiord districts tidal ranges have less impact -the waters are relatively calm and most boats fish round the clock.

HRC: Are birds killed when fishing occurs in local concentrations of Marbled Murrelets or are murrelets fairly scattered in their at-sea distribution near fishing boats?

MEI: Birds are generally scattered.

HRC: What sort of "stuff" accumulates on the nets that murrelets could be feeding on? - Is it that small fish feed off nets and then murrelets feed on the fish?

MEI: I presume that the "stuff" accumulating on the nets is zooplankton and not silt fines of glacier flour. I don't know if the fish are attracted to the nets to feed or for temporary "cover". The fore mentioned "balls of feed fish" which may include juvenile Herring, Sandlance, Capelin, Needlefish and various salmon fry are travelling against the current, come up against the net and are held there for a period of time before passing through or going around or under the net.

HRC: Is nearshore fishing "intensive" in your area? - Does gillnet fishing appear to be increasing or decreasing?

MEI: Nearshore fishing is locally intensive at times fish are travelling to their natal streams or rivers. Further offshore up to the 3 mile limit fish are less restricted and intensity decreases. Fishing is limited by permits. The numbers of permits will not increase and may in some areas decrease with a state buy-back program in areas where there are too many permits for the volume of salmon."

While the above observations apply to the 1970's, more recent comments by Isleib to A.R. DeGange reflected similar or greater amounts of mortality continuing throughout the 1980's (see DeGange et al. 1993). For southeastern Alaska, Isleib had estimated up to 1,000 Marbled Murrelets were taken annually in DeGange et al. (1993) but it is unclear if this estimate is based on more data than available in 1982 (see above). Only one bird was reported killed in offshore high-seas driftnet fishery near the western Aleutian Islands through 1988 (DeGange 1978, DeGange et al. 1985, Sealy and Carter 1984, Mendenhall 1992). However, murrelets do not usually occur far offshore and there does not appear to be a significant problem in offshore fisheries.

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