UNITED STATES POSTAL SERVICE
Hovercraft Transport of Alaska Bypass Mail
Ecological Monitoring Summary Report

Prepared for:

UNITED STATES POSTAL SERVICE

Prepared by:

US Department of Transportation
Volpe National Transportation Center
Cambridge, Massachusetts

and

Environmental Engineering Solutions
(a joint venture)
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March 2000

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Executive Summary

The United States Postal Service (USPS) has completed a 2-year demonstration program to transport bypass mail and non-priority mail by hovercraft on a year-round basis in the Yukon Delta of Alaska. The program involved Bethel and seven remote Alaskan villages along the Kuskokwim and Johnson Rivers. The villages were Kwethluk, Akiak, Akiachak, Napaskiak, Napakiak, Nunapitchuk, and Kasigluk. Bethel served as the base for mail transport to the seven villages. The July 1997 *Final Alaska Hovercraft Demonstration Project Environmental Assessment and Finding of No Significant Impact* (EA/FONSI) concluded that no significant impacts on the environment would result from use of the hovercraft to transport mail. The USPS agreed in the FONSI to conduct wildlife, fish, subsistence, and safety monitoring to obtain data on actual impacts of the hovercraft project. Toward this end, the USPS conducted an assessment of hovercraft technology and safety and has conducted ecological monitoring to investigate potential impacts to the ecological resources, the subject of this report.

Waterfowl resources were evaluated by determining flushing reactions in response to the hovercraft and motorboats, waterfowl use of habitats along the riverbanks, and waterfowl use of habitats outside of the riverbanks. The study involved conducting surveys of waterfowl abundance along sections of the rivers traveled by the hovercraft and along sections where the hovercraft does not operate. The study gave some insight into whether or not waterfowl were "leaving the area" as a result of the hovercraft and thus not available to subsistence hunters. Aerial transects were surveyed using fixed-wing aircraft in order to document breeding pairs and general waterfowl use of habitats in areas near the rivers. This enabled an evaluation of whether or not the hovercraft adversely affects the use of nearby habitats by waterfowl, and thus potentially the breeding capacity of the birds.

The flushing responses of approximately over 9,000 birds, nearly half of which were waterfowl, were observed over four monitoring campaigns (1997 to 1998). Waterfowl, which are important subsistence animals, were found to flush almost 100 percent of the time in response to both the hovercraft and motor boats.

Waterfowl numbers adjacent to the rivers were not affected by the presence of the hovercraft. Essentially, the same numbers of birds were found in the areas adjacent to where the hovercraft operated and in areas where it did not operate. Assùming the birds were available for breeding in the May season, the presence or absence of the hovercraft does not have a significant effect on breeding waterfowl nor on general use of habitat.

A total of 1,311 waterfowl were observed during motorboat surveys along the Kuskokwim, Johnson, and Pikmiktalik Rivers to compare waterfowl abundance along hovercraft routes with waterfowl abundance in reference areas. The results of these observations indicated that the hovercraft is not affecting waterfowl abundance along the Kuskokwim and Johnson Rivers, as numbers observed were similar to those in reference areas.

The potential for mortality to adult fish in the rivers was assessed by watching for floating (i.e., injured or dead) fish behind the hovercraft and in its wake. To assess the potential impact of the hovercraft on juvenile fish in shallow areas, study areas were established where the hovercraft was intentionally routed onto shallow beaches where small fish were known to be present. Beach seining was used to collect fish at these sites immediately following passage of the hovercraft to determine if the hovercraft was injuring fish in shallow areas. The investigation into potential fish stranding caused by the hovercraft's wake was based on the measurement of wave heights from the hovercraft's wake and on observations of dead or stranded fish on low-gradient beaches and at hovercraft landing sites. To assess if the hovercraft might be having an effect on subsistence gillnet fishing, test fishing studies were conducted to discern possible differences in catch rates when the hovercraft travels by a gillnet.

The hovercraft was followed by boat for a total of 263 miles on the Kuskokwim and Johnson Rivers during the seven monitoring campaigns from 1997 to 1999 in an effort to observe if the hovercraft's effect on adult fish mortality. No fish mortality or injury was observed after the hovercraft passed.

A total of 87 beach seinings were conducted in 1999, including 49 test seinings (immediately after the hovercraft passed) and 38 control seinings on the Kuskokwim and Johnson Rivers. There were no significant differences in the rates of injury to fish captured in the test seines to those in control seines.

A total of 85 stranded fish were observed at 73 hovercraft landing events in 1999. These few stranded fish are insignificant and would not represent an impact on the population.

A total of 101 paired netting tests, including both set nets and drift nets, were conducted on the Kuskokwim and Johnson Rivers. No significant difference resulted between the number of fish caught when the hovercraft passed or did not pass the nets.

The issues identified in the programmatic monitoring plan and from concerns identified by local citizens and groups are presented below, accompanied by their respective answers as determined from the ecological monitoring program.

- Is there a difference in behavioral responses of waterfowl to hovercraft versus other watercraft, and if so, what is the difference? **No difference was observed. Waterfowl flushed in similar amounts from the hovercraft and motorboats. Waterfowl did not alter their use of habitat nor the amount they used any particular habitat associated with the Kuskokwim and Johnson Rivers.**
- Is the nesting success of waterfowl along the river routes of the hovercraft affected by the hovercraft's passage? **No effect was observed. Based upon aerial and motorboat surveys of the Johnson and Kuskokwim Rivers, the hovercraft had no discernible effect on nesting success. The results are based upon the facts that waterfowl abundance during breeding season and later during brooding and rearing showed no relationship to hovercraft operational and non-operational areas on the rivers.**
- Are adult fish being injured or killed by the hovercraft? **No. No adult dead or injured fish were observed where the cause of harm was attributable to the hovercraft, despite considerable efforts to observe such a result.**
- Are juvenile fish being injured or killed by the hovercraft as it passes over shallow water? **Juvenile fish populations were not being significantly harmed based upon observations of injured fish attributable to the hovercraft after it was directed to pass by in shallow water.**
- Do juvenile fish become stranded by the wake of the hovercraft in shallow areas of the rivers, and if so, are they at greater risk than from conventional watercraft? **Juvenile fish were not stranded in significant numbers. Indeed, numbers of stranded fish from the hovercraft**

operating in shallow water areas or at landing sites are negligible when compared to the numbers of fish documented to be in the shallow water areas.

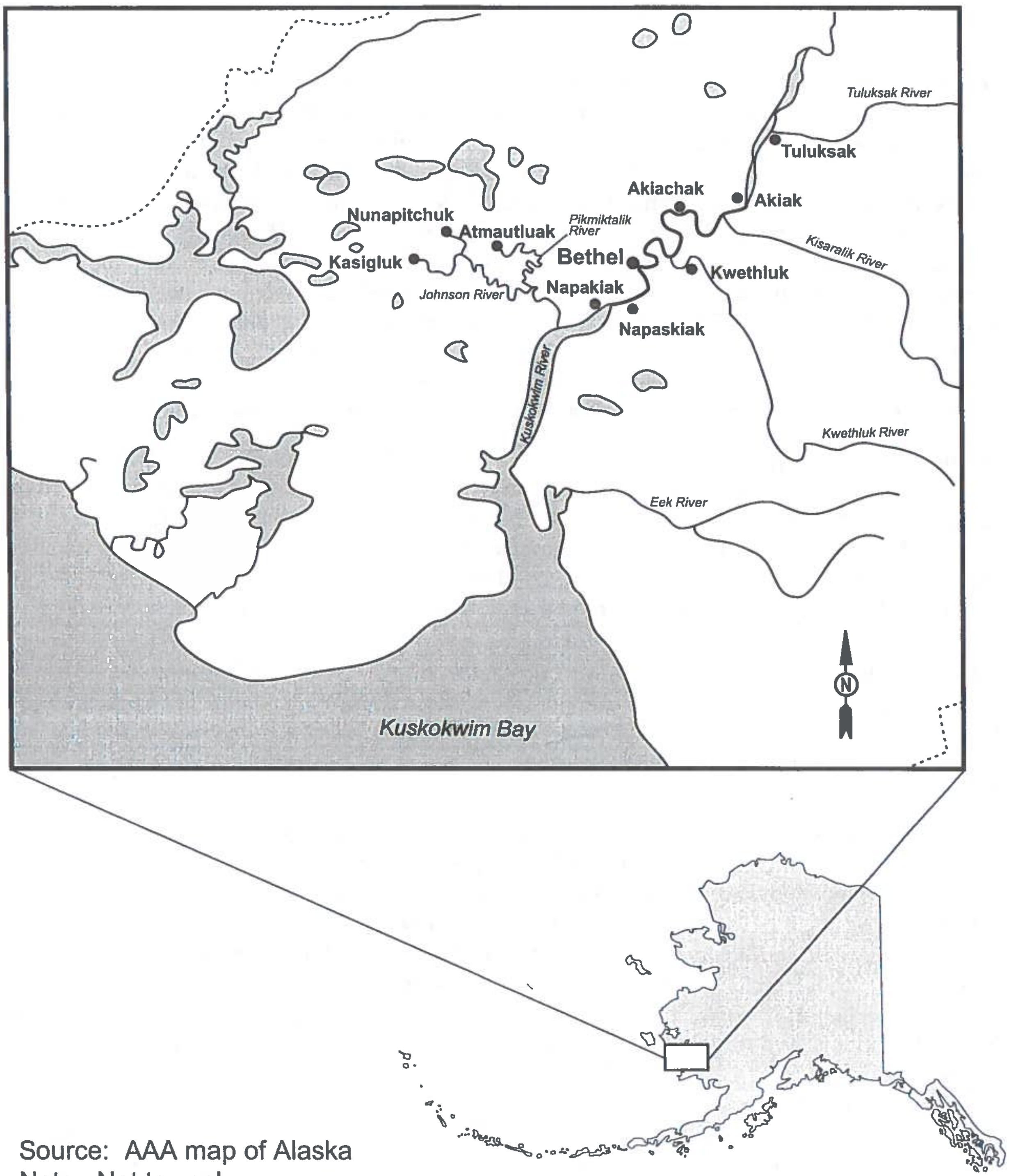
- Does the hovercraft impact subsistence fishing and, if so, in what manner? **No. The hovercraft did not affect gillnet fishing success, nor did it have a significant effect on blackfish behavior that adversely affected fishing success.**

1.0 Introduction

The United States Postal Service (USPS) has completed a 2-year demonstration program to transport bypass mail and non-priority mail by hovercraft on a year-round basis in the Yukon Delta of Alaska (Figure 1.1). The program involved Bethel and seven remote Alaskan villages along the Kuskokwim and Johnson Rivers. The villages were Kwethluk, Akiak, Akiachak, Napaskiak, Napakiak, Nunapitchuk, and Kasigluk. Bethel served as the base for transport of bypass and non-priority mail to the other seven villages. The July 1997 *Final Alaska Hovercraft Demonstration Project Environmental Assessment and Finding of No Significant Impact* (EA/FONSI) concluded that no significant impacts on the environment would result from use of the hovercraft to transport mail. The USPS agreed in the FONSI to conduct wildlife, fish, subsistence, and safety monitoring to obtain data on actual impacts of the hovercraft project. Toward this end, the USPS conducted an assessment of hovercraft technology and safety and has conducted ecological monitoring to investigate potential impacts to the ecological resources, the subject of this report.

The successful scoping of the monitoring effort was aided by considerable input from local residents and regulatory agencies. To guide the ecological monitoring efforts and to ensure that the monitoring addressed concerns expressed by the public and regulatory agencies, the USPS prepared a programmatic monitoring plan to investigate impacts to wildlife, fish, and subsistence (*Alaska Hovercraft Demonstration Project Ecological Monitoring Plan*, USPS, August 1997) (1997 Monitoring Plan). Upon completion of the monitoring described in the 1997 plan, the USPS summarized the results in a report (*United States Postal Service Alaska Hovercraft Demonstration Project Ecological Monitoring 1997-98 Summary Report*) (1997-98 Summary Report). A second monitoring plan was developed prior to the 1999 ecological monitoring (*Alaska Hovercraft Demonstration Project Ecological Monitoring Plan*, USPS, April 1999) (1999 Monitoring Plan) to refine and focus the second year of monitoring based upon local input and the results of the monitoring conducted during 1997-98.

Prior to preparation of the 1997 plan, a meeting was held with representatives of the Alaska Department of Fish and Game (ADFG) to discuss possible methods to be used in the monitoring. Following this meeting, several telephone conferences were held during July and August 1997 with ADFG and the U.S. Fish and Wildlife Service (USFWS) to further refine the studies that were to be detailed in the 1997 plan. The draft and final 1997 monitoring plans were reviewed and coordinated with interested parties, including the Hovercraft Committee. The Hovercraft Committee consisted of representatives from each village, the Bethel Mayor, Association of Village Council Presidents, and other government regulatory agencies. The government regulatory agencies included USFWS, US Coast Guard, ADFG, Alaska Department of Environmental Conservation, and Alaska Division of Governmental Coordination (including Coastal Zone Management). Team members met with ADFG and USFWS representatives in August 1997 to obtain input into the design of the monitoring studies to be conducted in 1998. The monitoring team attended a public meeting in 1998 for the purpose of explaining the studies and obtaining feedback. The monitoring team leader attended a hovercraft meeting in May 1998 for similar purposes as well as to give a briefing on the results observed to that date. During 1998, team



Source: AAA map of Alaska
Note: Not to scale

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Project Locus Map

USPS Transport of Alaska Bypass Mail by Hovercraft
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Figure 1.1

members interviewed a number of village representatives by telephone as well as in person to obtain feedback on the studies, to hear concerns, and to gain assistance with choosing appropriate locations for the studies.

The draft version of the 1997-98 Summary Report was also coordinated with the villages and Hovercraft Committee. The final version of the report was reviewed by village residents, the Hovercraft Committee, and the more than 40 residents who submitted an issue report regarding an ecological matter. No comments were received from this distribution. Additionally, the results of the 1997-98 monitoring efforts were presented to the villages in February 1999 with the aid of a Yupik interpreter. Comments on this report received during the village presentations were considered in the development of the 1999 Monitoring Plan.

The 1999 Monitoring Plan was coordinated with the same individuals and organizations as the 1997 Monitoring Plan as well as the more than 40 people who submitted an issue report or who requested a copy during village presentations held in February 1999. Additional telephone conferences were held with ADFG and USFWS regarding technical methodologies of the 1999 monitoring. Team members met with ADFG and USFWS representatives in 1998 and 1999 to obtain input into the design of the monitoring studies to be conducted in 1999. Comments received on the plans and in meetings or issue reports were incorporated into the final studies. Feedback on the proposed studies and plans was also obtained during numerous special meetings and interviews held for that purpose. As in 1998, the entire monitoring team attended a public meeting in 1999 for the purpose of explaining the studies and obtaining feedback. Team members again interviewed village representatives by telephone as well as in person to obtain feedback on the studies, to hear concerns, and to gain assistance with choosing appropriate locations for conducting the studies that year.

According to the programmatic monitoring plan and concerns identified by local citizens and groups, the issues addressed included:

- Is there a difference in behavioral responses of waterfowl to hovercraft versus other watercraft, and if so, what is it?
- Is the nesting success of waterfowl along the river routes of the hovercraft affected by the hovercraft's passage?
- Are adult fish being injured or killed by the hovercraft?
- Are juvenile fish being injured or killed by the hovercraft as it passes over shallow water?
- Do juvenile fish become stranded by the wake of the hovercraft in shallow areas of the rivers and, if so, are they at greater risk than from conventional watercraft?
- Does the hovercraft impact subsistence fishing and, if so, in what manner?

The Alaska Hovercraft Ecological Monitoring Program evaluated the nature and extent of impacts, if any, from use of the hovercraft to fish, waterfowl, and subsistence efforts. The intent was not to quantify the exact number of fish or birds that might be affected by the hovercraft. The EA/FONSI did not claim that no impact to these resources would occur, but instead concluded that negative impacts would not be significant. The monitoring was designed to provide information to support or refute the conclusion that there is no significant adverse impact to fish and bird resources and thus to subsistence efforts focused on those resources.

This report documents monitoring methods and presents results of the data collected during the monitoring program. It also provides analysis, interpretations, and conclusions regarding the objectives of the ecological monitoring program. Within the primary sections (Methods, Results, and Summary) are subsections focused on waterfowl and fish resources.

The draft version of this Ecological Monitoring Study Report was sent for review to all the regulatory agencies involved with the project, as well as all Hovercraft Committee members, and all the people who submitted issue reports or requested a copy. A list of the persons who were sent a copy of the draft report is included in Appendix H.

2.0 Methods

Monitoring was conducted in accordance with the 1997 and 1999 Monitoring Plans. As anticipated, some minor field changes and refinements of procedures were implemented during the monitoring campaigns. This report documents the methods actually used during the seven monitoring campaigns.

Monitoring dates were:

- September 9-18, 1997
- May 18-23, 1998
- July 7-11, 1998
- August 19-25, 1998
- June 15-24, 1999
- July 7-13, 1999
- August 13-21, 1999

The methods that follow describe the monitoring efforts and analysis techniques used to interpret the data. The methodology also includes a discussion of the statistical analyses of the data, where appropriate. More detail of statistical methods and analyses is presented in Appendix B.

2.1 Waterfowl Resources

The ecological monitoring was designed to evaluate possible effects on waterfowl potentially affected by the hovercraft. Although the study focused on waterfowl because of their subsistence importance, other species groups were recorded as well, particularly in the 1997-98 efforts. During the first year of monitoring, waterfowl resources were evaluated using a three-pronged approach. The approach included recording flushing distances from the hovercraft and motorboats, waterfowl use of habitats along the riverbanks, and waterfowl use of habitats outside of the riverbanks.

Based on the results of the 1997-98 monitoring efforts, the 1999 monitoring efforts were refocused to look at larger scale indications of disturbance. The monitoring team had found that it was impractical to measure directly the site fidelity of individually flushed birds because of the limited time and resources available. Additionally, because 1997-98 monitoring indicated that many waterfowl species (ducks, geese, and swans) flushed nearly all the time in response to both the hovercraft and motorboats, the 1999 monitoring was focused on determining at a fundamental level whether or not birds used operational areas (river areas traversed by the hovercraft) differently than non-operational areas (not traversed). The 1999 monitoring evaluated waterfowl resources by observing the effect of the hovercraft on numbers of waterfowl along the rivers and noting its effect on waterfowl use of areas adjacent to the rivers.

2.1.1 Flushing of Waterfowl

The monitoring for potential effects on bird resources along hovercraft routes consisted of a combination of monitoring for evidence of direct behavioral effects, as evidenced by flushing reactions of birds in relation to the hovercraft, and monitoring of waterfowl abundance along the rivers where the hovercraft operates. The behavioral observations of flushing reactions consisted of two components – flushing observations from moving watercraft and flushing observations from stationary locations. These observations were conducted as part of the 1997-98 monitoring efforts.

Flushing Observations Made from Moving Watercraft

The team recorded waterfowl flushes in response to both the hovercraft and motorboats (16 to 25 feet in length) by direct observation while riding these crafts. Observations were made from the hovercraft and from motorboats as they traveled along the Kuskokwim and Johnson Rivers at about 30 knots. Data were collected from motorboats on days the hovercraft did not access a particular reach of river.

Birds were observed by type and family or species when possible, although data were combined in general groups for analysis (e.g., waterfowl). Identification to species was often difficult due to weather conditions, movement and speed of the craft, and distance from the birds. Bird locations (determined using a handheld Global Positioning System [GPS] unit), bird group, and number of individuals were recorded on a data sheet along with general habitat information, response, closest approach, and number flushed.

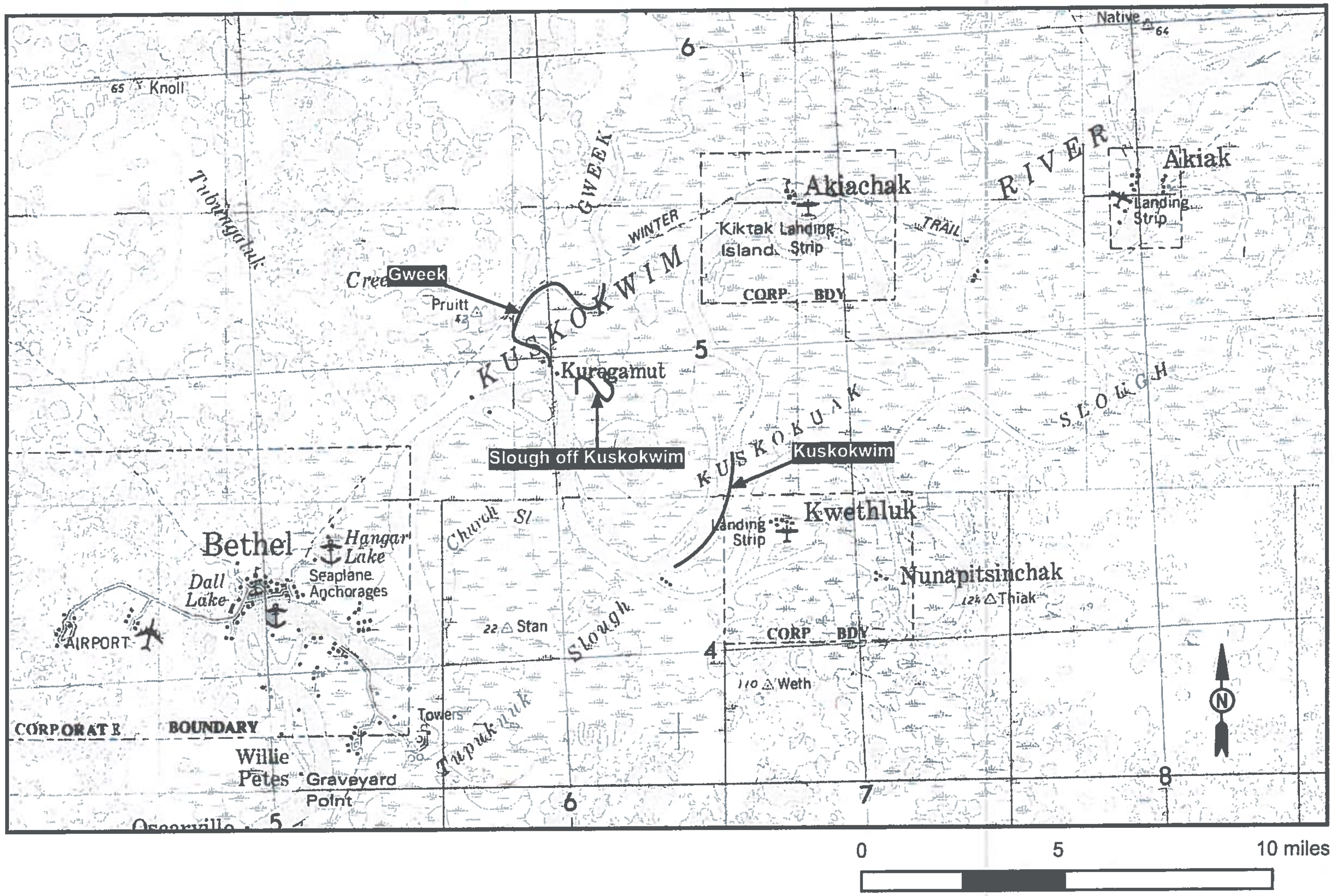
Flushing Observations Made from Stationary Locations

Observations of flushing from stationary locations were attempted at two beaches on the Kuskokwim, and at other beaches along the Johnson and Kuskokwim, when conditions permitted as part of the wake characterization and fish stranding studies. Observers recorded the effects of the hovercraft and other river crafts on the behavior of various birds when possible. The reactions of birds using the beach at the time various watercraft were passing by were observed and characterized. Birds that reacted to the disturbance were observed to the fullest extent possible to characterize post-disturbance behavior. Attempts were made to observe birds at all of the other beaches while studying fish stranding but invariably no birds were using those locations.

2.1.2 Waterfowl Use of River Habitat

Because of the importance of subsistence gathering along the rivers and in response to village residents' concerns, a study of waterfowl use of river habitats was added to the monitoring program in 1999. The study involved conducting surveys of waterfowl abundance along sections of the rivers traveled by the hovercraft and along sections where the hovercraft does not operate. In the spring and summer the waterfowl observed would be representative of use by local breeding waterfowl and waterfowl broods, whereas in August waterfowl observed would likely be birds preparing to migrate. Therefore, the study gave some insight into whether or not waterfowl were "leaving the area" as a result of the hovercraft and thus not available to subsistence hunters. The objective of the investigation was to discern whether differences in numbers could be attributable to the hovercraft. The specific areas surveyed were selected after coordination with village residents and the USFWS who provided input on areas that they thought would represent good waterfowl habitat.

Based upon this input, five transects (Figures 2.1 and 2.2) were identified:



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Motorboat Waterfowl Survey Transects - Part 1

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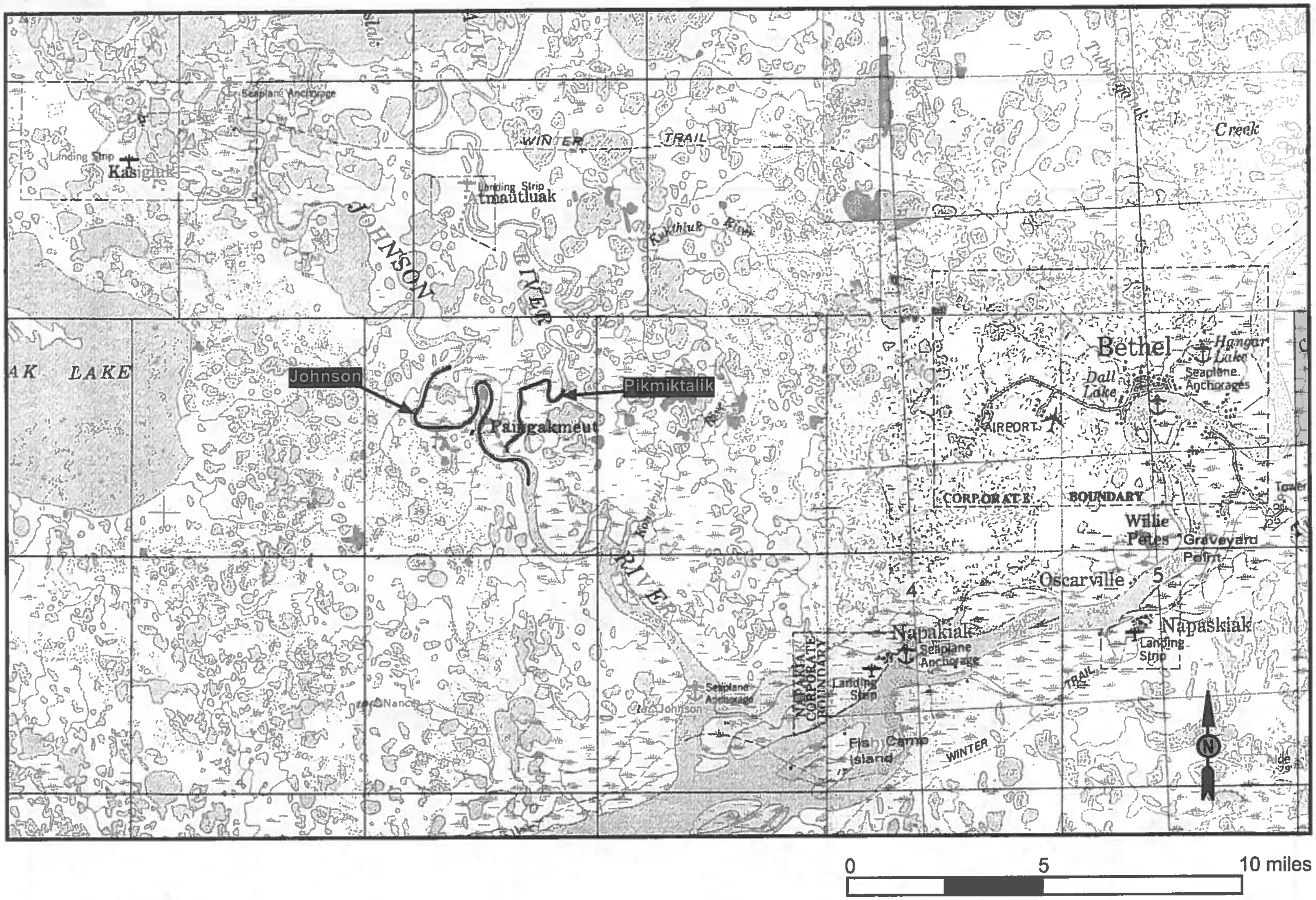
Figure 2.1



Motorboat Waterfowl Survey Transects - Part 2

USPS Transport of Alaska Bypass Mail by Hovercraft
Ecological Monitoring Summary Report

Figure 2.2

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- Johnson River in the area where the hovercraft operates
- Pikmiktalik River where the hovercraft does not operate
- Kuskokwim River where the hovercraft operates
- Slough off the Kuskokwim River
- Lower reaches of the Gweek River

The slough on the Kuskokwim River was used because, based on the bird biologist's judgement, it represented high-quality non-river waterfowl habitat within the operational area of the hovercraft that was not traveled by the hovercraft and likely seldom traveled by other craft. The Gweek River was suggested by the USFWS as a good choice because it was a known waterfowl area and was also surveyed by them as part of their annual census. The Gweek River and the slough used in this study had less boat traffic than the Kuskokwim River. Therefore, the lesser amount of disturbance in these areas could have contributed to waterfowl use there. The amount of area surveyed and areas of the rivers included were determined by the amount of time required to travel the rivers by boat (at 20 mph) and the need to conduct other investigations (aerial surveys) at the end of the day.

Transects were laid out to be as long as possible but still fit into the monitoring day schedule. Although every effort was made to make the transects as similar to each other as possible, some habitat changes occurred with each transect (something that could not be controlled). The longer length of transects served to minimize this potential variation. Transect lengths were varied to ensure that each transect had representative amounts of the varying habitat types present along that particular transect. For example, the length of the Kuskokwim Slough transect was set to ensure that the habitats present in that area of the slough were appropriately represented in the transect; thus the observations of waterfowl along the transect would represent an "overall" river slough habitat.

Waterfowl were observed during each of the monitoring days of the 1999 effort by driving the boat near shore and keeping the distance from shore as consistent as possible between transects and between days. Only waterfowl on the shoreward side of the boat were recorded, since this is where the best habitat existed. The same guide and observer conducted all the surveys for all the days, thereby avoiding observer or methodology bias in the data. Waterfowl abundance along the transects, as indicated by numbers observed per mile of transect, were compared statistically using the Kruskal-Wallis one-way analysis of variance on ranks and the Mann-Whitney Rank Sum Test, as appropriate (Appendix B). Standardization of the observations on a per mile basis eliminates most bias from the variable lengths of transects.

2.1.3 Breeding Waterfowl

Aerial transects were surveyed using fixed-wing aircraft in order to document breeding pairs and general waterfowl use of habitats in areas near the rivers. This enabled an evaluation of whether or not the hovercraft adversely affects the use of nearby habitats by waterfowl, and thus potentially the breeding capacity of the birds. The general presence of waterfowl, as indicative of breeding waterfowl, was used as an index for nesting activity.

Aerial surveys for breeding waterfowl and other birds were conducted on six days, May 18-23, in 1998 by flying over 27 transects. These transects plus two transects on the Johnson River and two transects on the Pikmiktalik River were surveyed during each monitoring campaign of 1999. The transects, each about four kilometers in length, were originally laid out on a map to represent "equal" proportions of habitat and were positioned so that they crossed one of the rivers. Transects were located from the air using GPS and coordinates obtained from the maps (Appendix A). Seven test transects were located on the Kuskokwim River between the Johnson River and

Akiak (Figures 2.3 and 2.4), 11 test transects on the Johnson River (Figure 2.4), six control transects on the Kuskokwim River upstream of the Akiak reference area (Figure 2.5), and 7 control transects on the Pikmiktalik River, the reference area for the Johnson River (Figure 2.4). Each of the 31 transects were surveyed on six days of each campaign in June, July, and August 1999.

The aerial survey transects were flown perpendicular to the rivers using fixed-wing aircraft, at the same speed (about 70 mph ground speed) and altitude (300 ft). Survey methodology was adapted from USFWS methods described by Butler et al. (Wildlife Society Bulletin 1995, 23:148-154). Nesting birds, individual birds, and groups of birds were recorded by species or species groups and number of individuals for each transect. The same observers, one in the copilot's seat and one in the rear seat, flew on each flight. The same individual conducted the observations from the same seat for all the flights. The same plane, a Cessna 172, and one of two pilots were used on every flight. Both pilots were experienced at flying aerial surveys for waterfowl.

The transects used in aerial surveys of breeding waterfowl were video-taped in August 1999 to determine whether or not there were significant differences in the habitats between transects and areas. Significant differences in habitats would affect the number and type of waterfowl observed. For example, transects with significantly greater amounts of marsh and pond habitat would be expected to have greater densities of nesting waterfowl than transects devoid of those habitats. For this reason, an understanding of the habitats present on the transects was necessary before differences in waterfowl between transects could be determined.

Habitats were quantified by viewing the tape of the aerial transects and observing the time it took for five habitat types (forest, marsh, unforested upland/tundra, river/lake, stream/pond/slough/mudflat) to pass by a point in the center of the screen. A good analogy is that a pencil was held still, while the photo was dragged underneath it to develop the sampling transect. Cumulative times of each habitat for each transect were divided by the total time of the transect to yield percent coverage by each cover type in that transect. This method allowed comparison between transects by eliminating potential biases that could result in slight differences in altitude and ground speed.

The methodology for the aerial waterfowl counts differed slightly between the 1998 and 1999 monitoring campaigns. Waterfowl were only counted in two zones on the transects in the 1998 surveys: on the river and off the river. In 1999, waterfowl were counted in three zones on the transects: on the river, in a <200 yard zone on either side of the river, and off the river, as determined by >200 yards away from the river. Since the amount of transect in the three zones varied between transects, the amount of each zone was quantified to standardize the waterfowl counts for abundance in these areas to number of waterfowl per transect per unit length of category. Habitats along the control and Kuskokwim River transects and the Johnson River and Pikmiktalik River transects were compared using the Mann-Whitney *U* test. The Mann-Whitney *U* test is a non-parametric statistical method designed to test the hypothesis that two random samples have been drawn from populations having identical statistical distributions (Appendix B). These comparisons were made to determine if significant differences in waterfowl use existed among the three habitat zones surveyed, when each river where the hovercraft operates was compared with its respective reference area. Significant differences in waterfowl use would suggest that an effect on waterfowl behavior was occurring.

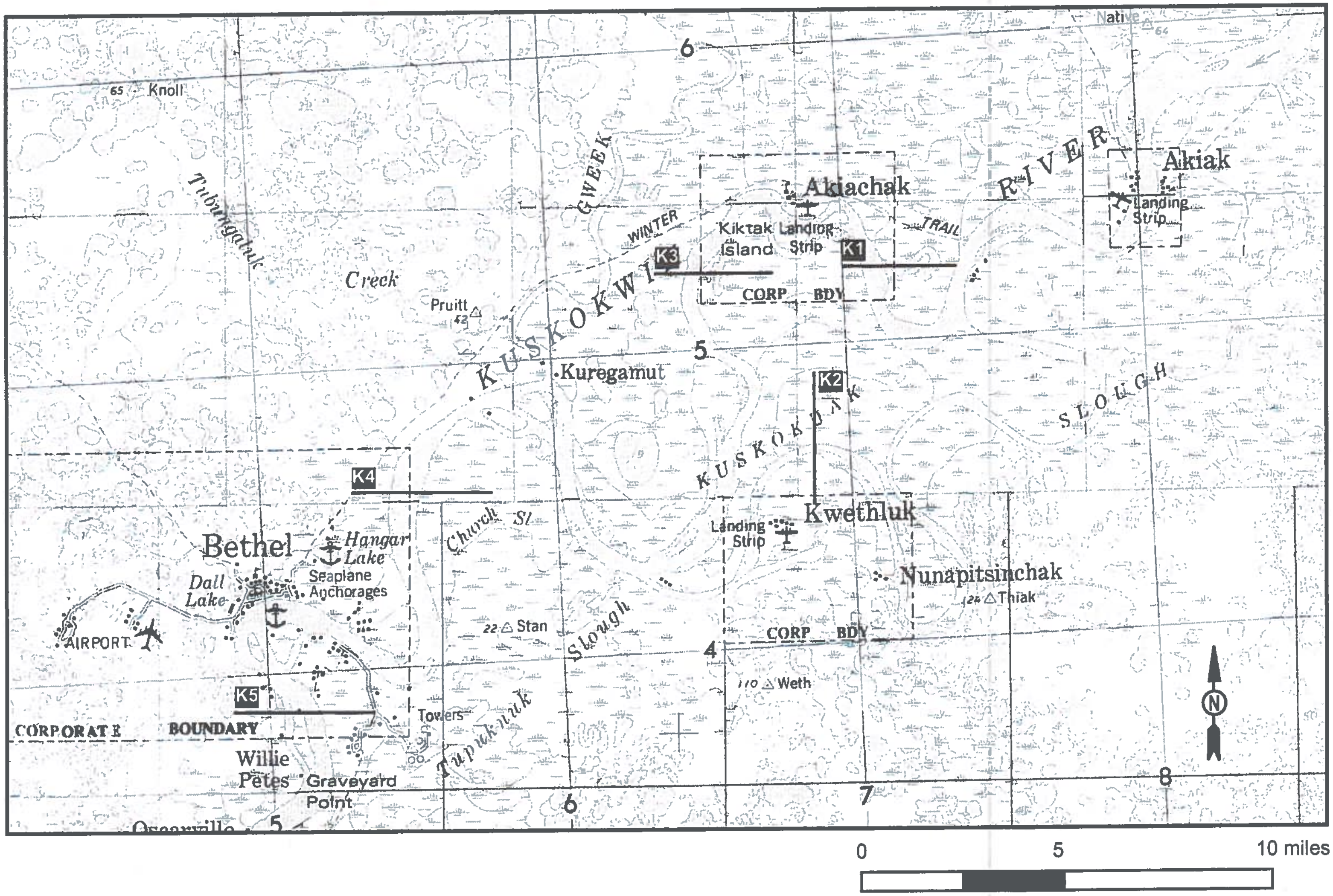

Figure 2.3

Aerial Waterfowl Survey Transects - Part 1

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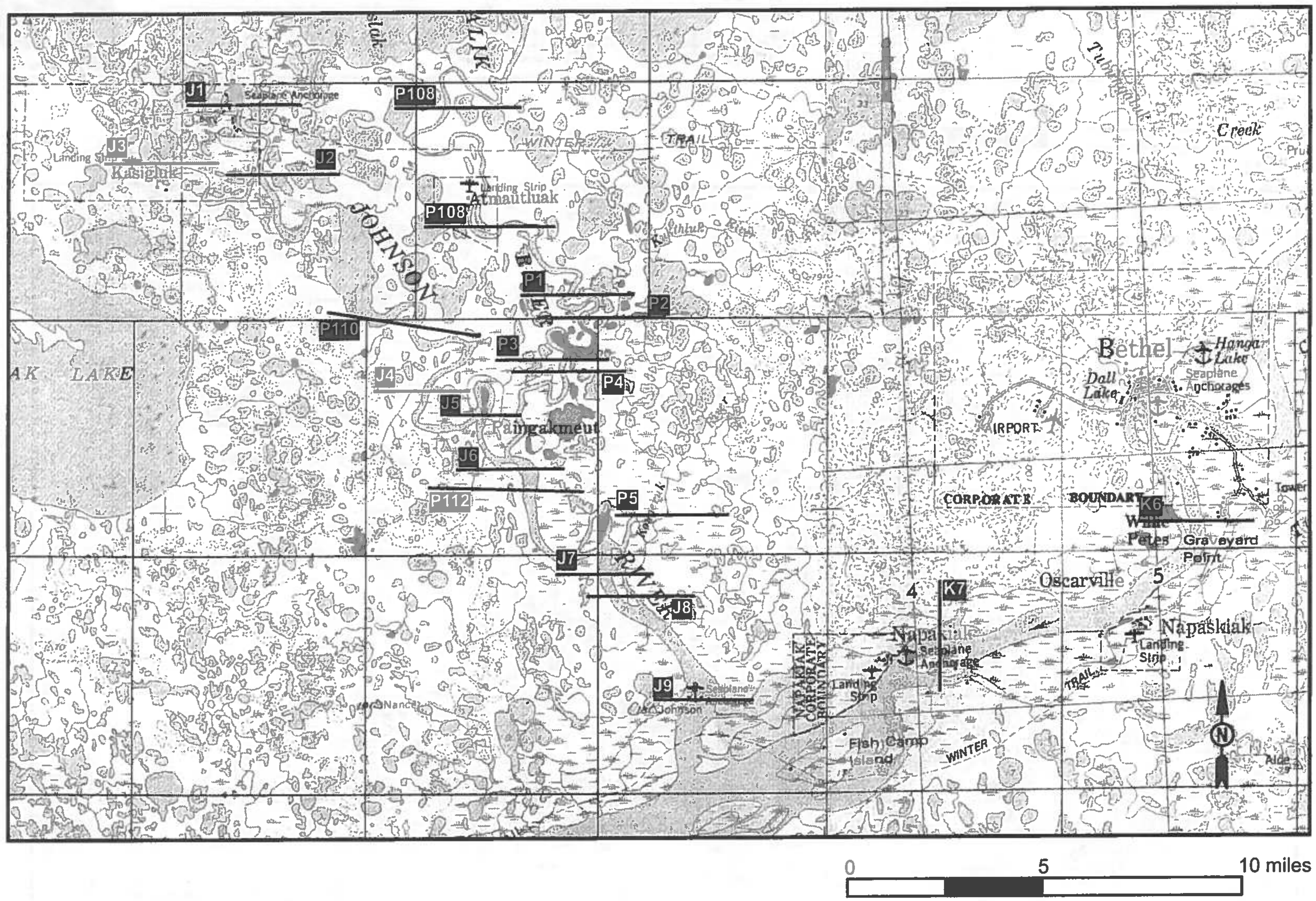

Aerial Waterfowl Survey Transects - Part 2

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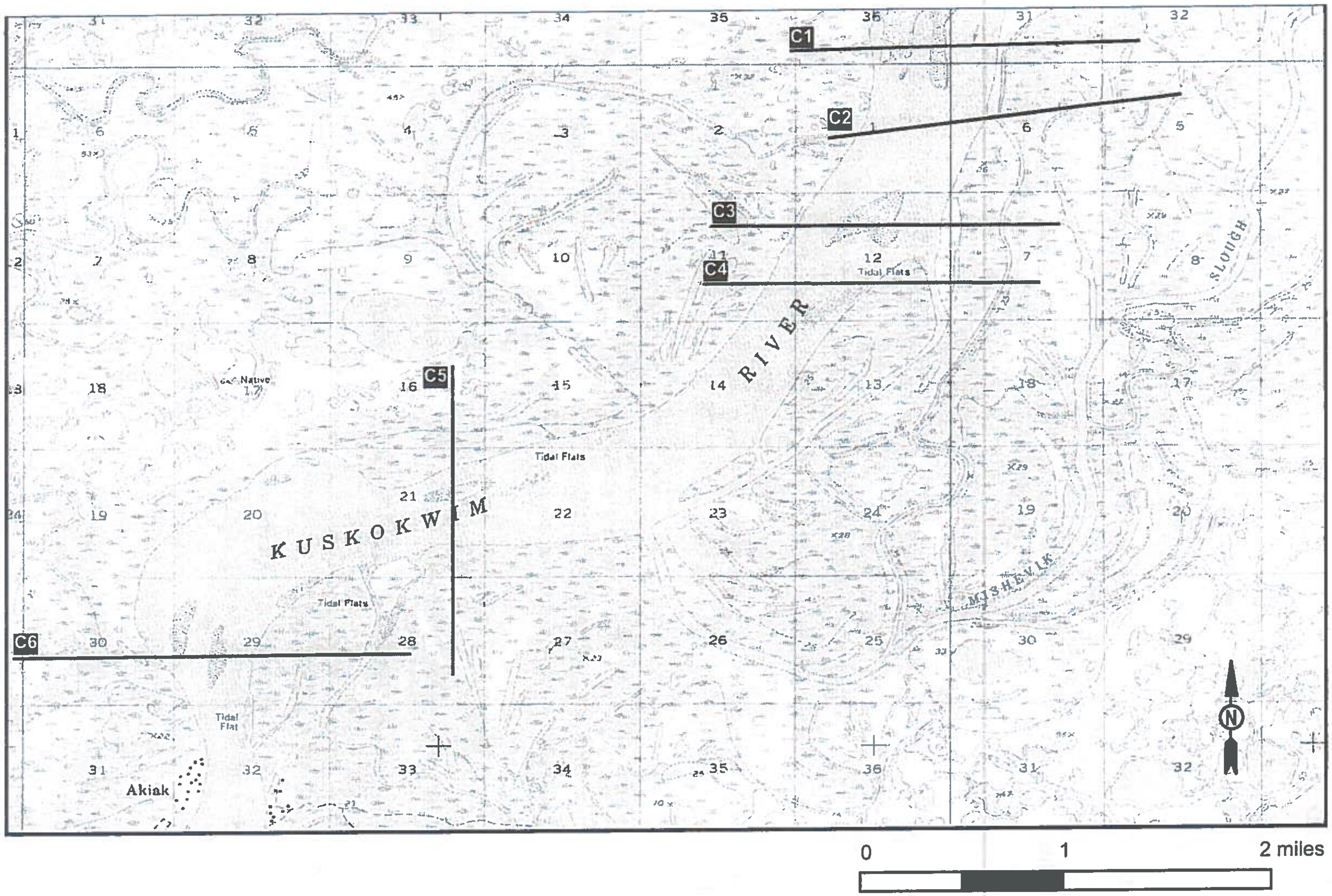
Figure 2.4



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Aerial Waterfowl SurveyTransects - Part 3

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Figure 2.5

2.2 Fish Resources

The investigation into possible hovercraft-related detrimental effects on fish resources was implemented through a four-pronged approach. This included:

- Monitoring for adult fish that were injured or killed by the hovercraft
- Monitoring for direct injury or mortality to juvenile fish that were injured or killed by the hovercraft in shallow areas of the rivers
- Monitoring the potential for the hovercraft to strand fish on low-gradient beaches and hovercraft landing sites
- Monitoring for possible effects on subsistence fishing success

2.2.1 Potential Adult Fish Mortality

The potential for mortality to adult fish in the rivers was assessed by watching for floating (i.e., injured or dead) fish behind the hovercraft and in its wake as well as in other areas of the rivers. The intent was to first establish the scope of the issue, and then if observations suggested it was warranted, to establish control points to place the observations in proper perspective. This monitoring activity was instituted in response to an Issue Report that fish were floating to the surface after the hovercraft passed by (received August 25, 1997). Dead and dying fish, mostly spawned out salmon, are commonly observed floating in the river. While it seemed implausible that the hovercraft, which does not directly contact the water, could kill a larger fish, it was decided nevertheless to address the issue during the 1997-1998 monitoring campaigns and again in 1999. The Committee was informed at its September 26, 1997 meeting that the team added this activity to the monitoring, despite it not being in the 1997 Monitoring Plan.

These observations were conducted by watching for fish from a motorboat both while following and not following the hovercraft. In 1998 observations were made while following the hovercraft. This activity was expanded in 1999 to include observation at all times while boating on the rivers, regardless of whether the hovercraft was immediately ahead. During 1999, each monitoring team member recorded the distance traveled each day while following the hovercraft at various time intervals and while not following the hovercraft, as well as the number, location, and condition of any floating fish observed.

The monitoring team was prepared to collect freshly killed adult fish found along the rivers for the purpose of conducting necropsies to identify the cause of death. The USFWS volunteered the use of their local lab for this purpose.

At the suggestion of USFWS, to verify the existence of the potential for impacts while monitoring, part of the hovercraft travel routes were checked during 1999 with sonar for the presence of fish (as based on sonar returns) on selected days of the hovercraft's passage. The sonar surveys were generally conducted before the hovercraft began operations on a given day. Sonar surveys were conducted on two predetermined stretches of the Kuskokwim River, roughly five miles long, along the hovercraft's route (Figure 2.6). The sonar surveys were performed by traversing zigzag transects along the river using GPS referenced waypoints. After initial field testing, a gain setting and motorboat speed that produced optimal sonar performance were chosen and used for all subsequent surveys to maintain consistency.

FIGURE 2.6: Sonar Surveys on the Kuskokwim River

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2.2.2 Potential Juvenile Fish Mortality in Shallow Water Areas

Occasionally, the hovercraft travels near the shore over shallow water not associated with landing areas. There was a concern that the turbulence caused by the rapid water displacement under the craft could injure or kill small fish in those shallow areas. To assess this potential impact, study areas were established where the hovercraft was intentionally routed onto shallow beaches where small fish were known to be present and where sampling would be effective (Figures 2.7 and 2.8).

Beach seining was used to collect fish at these sites immediately following passage of the hovercraft. These catches were examined for injured or dead fish. Because the collection gear and necessary fish handling can cause injury and mortality, it was also necessary to sample nearby control sites prior to hovercraft passage.

Beaches were seined in the Johnson and Kuskokwim Rivers. The methods were coordinated with village representatives who suggested beaches where stranding was likely. These beaches plus additional beaches were evaluated based upon the monitoring team's observations and river conditions.

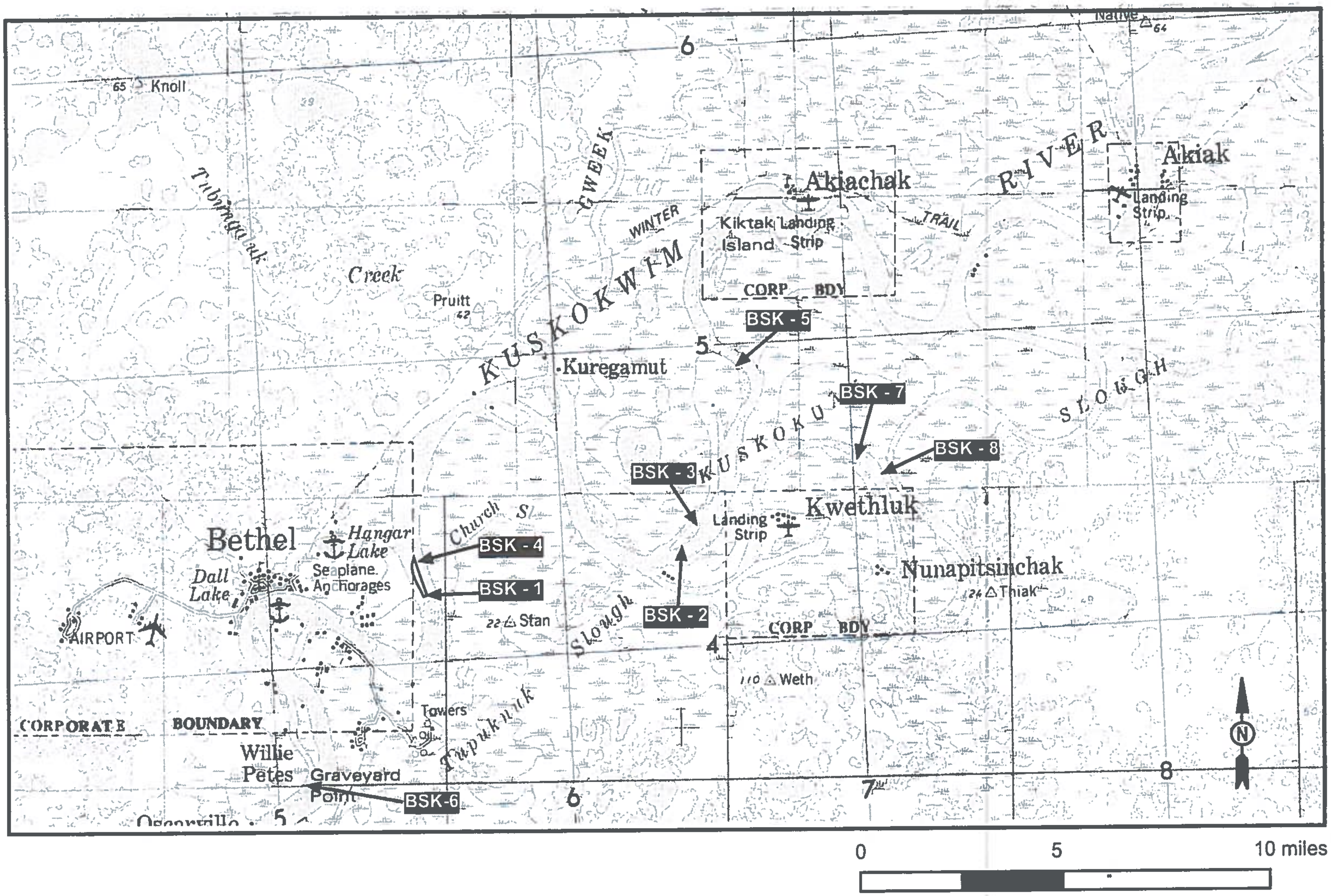
The observation area at each monitoring station was marked with two buoys placed parallel to shore approximately 50 feet apart and about 50 feet from shore. The area between the shoreline and the buoys was considered the observation area. The hovercraft was directed to pass between the shoreline and the buoys. After the hovercraft passed through the observation area, a 100-foot beach seine was deployed immediately at the downstream end of the observation area and as much of the area as possible between the buoys and the shoreline was enveloped. The seine was swept in an arc upstream to enclose the observation area and the two ends were pulled together at the shore to fully enclose the sampling area. Deploying at the downstream end and sweeping upstream ensured that any immobilized fish would float into the net and not away from the net (Figure 2.9).

Species, numbers, and approximate sizes of all fish caught were recorded. The conditions of fish caught were recorded as unharmed, injured, or dead. All uninjured fish were released as quickly as possible. After seining was completed, the beach was checked for stranded fish, if time and conditions allowed.

To evaluate whether dead or injured fish caught in the seine might be the result of fish handling rather than the hovercraft, up to two control seinings were conducted per day in similar shallow areas to check for injuries or mortality caused by the seining. These control sets were generally conducted in adjacent beach areas (just downstream) prior to the hovercraft's passage through the area. The beach seining data were statistically analyzed using a chi-square contingency table to determine if the proportion of dead or injured fish caught were significantly different between test and control sets. This analysis is explained further in Appendix B.

2.2.3 Stranded Fish on Beaches and Landing Sites

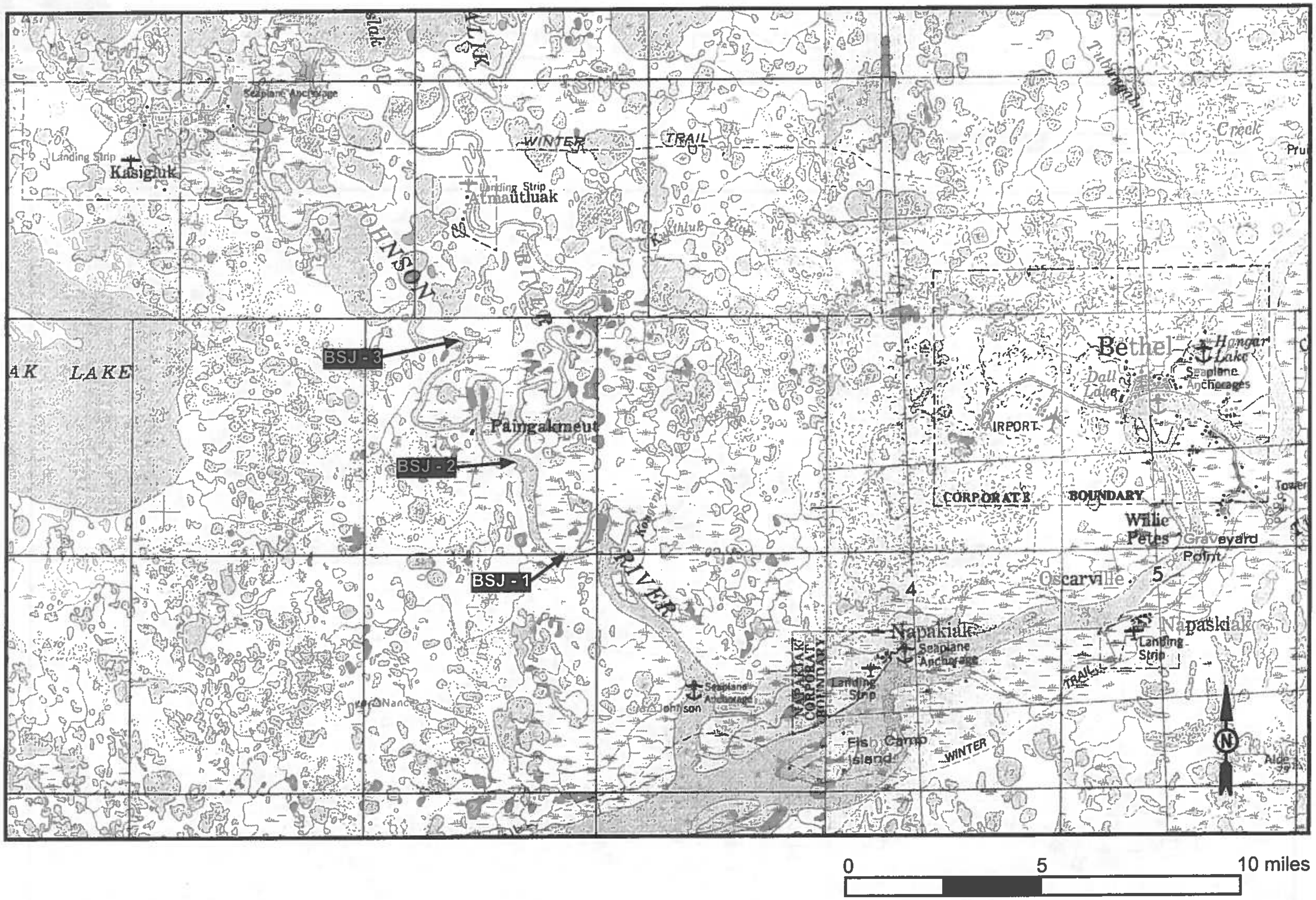
The investigation into potential fish stranding caused by the hovercraft's wake was based on the measurement of wave heights from the hovercraft's wake and on observations of dead or stranded fish on low-gradient beaches and at hovercraft landing sites. This study allowed the evaluation of the potential for fish stranding as compared to other water craft.



Beach Seining Locations on the Kuskokwim River

USPS Transport of Alaska Bypass Mail by Hovercraft
Ecological Monitoring Summary Report

Figure 2.7



Beach Seining Locations on the Johnson River

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Figure 2.8

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Hovercraft passing seining area in shallow water

Drawing in seine

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Shallow Water Seining

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Figure 2.9

Wake Characteristics

To determine whether the hovercraft has the potential to strand fish, an understanding of the characteristics of the wake (wave) that it produces is necessary. Simply put, there would have to be a high enough and long enough wave to lift and place fish on the beach. In addition, it is also necessary to understand its wake relative to other craft using the river. If the hovercraft's wake was similar to that of most other craft using the river, the importance of the potential for stranding would be diminished considering the considerable amount of traffic on the river. This part of the monitoring evaluated these two components of the potential for stranding.

Only beaches that had the necessary flat slope conducive to stranding were observed. A number of physical measurements were made to characterize the wave response on these beaches. Prior to an observation event, the characteristics of the beach were recorded, including length, width, slope, substrate, location, and beach type. Most monitoring sites (Figures 2.10 and 2.11) were about 200 yards long. A measuring stick was pushed into the beach at the edge of the waterline to measure the height of waves produced by the hovercraft and other boats. When the hovercraft or other boats passed by, the resulting crest heights, surge heights, and surge distances were measured. Crest height is the height of a breaking wave face. Surge height is the maximum height of a wake as the wave drives up the beach. Surge distance is the distance a wave surge drives up the beach. Other recorded information included the type, length, size of motor, and speed of the boat and the distance of the boat from the shore.

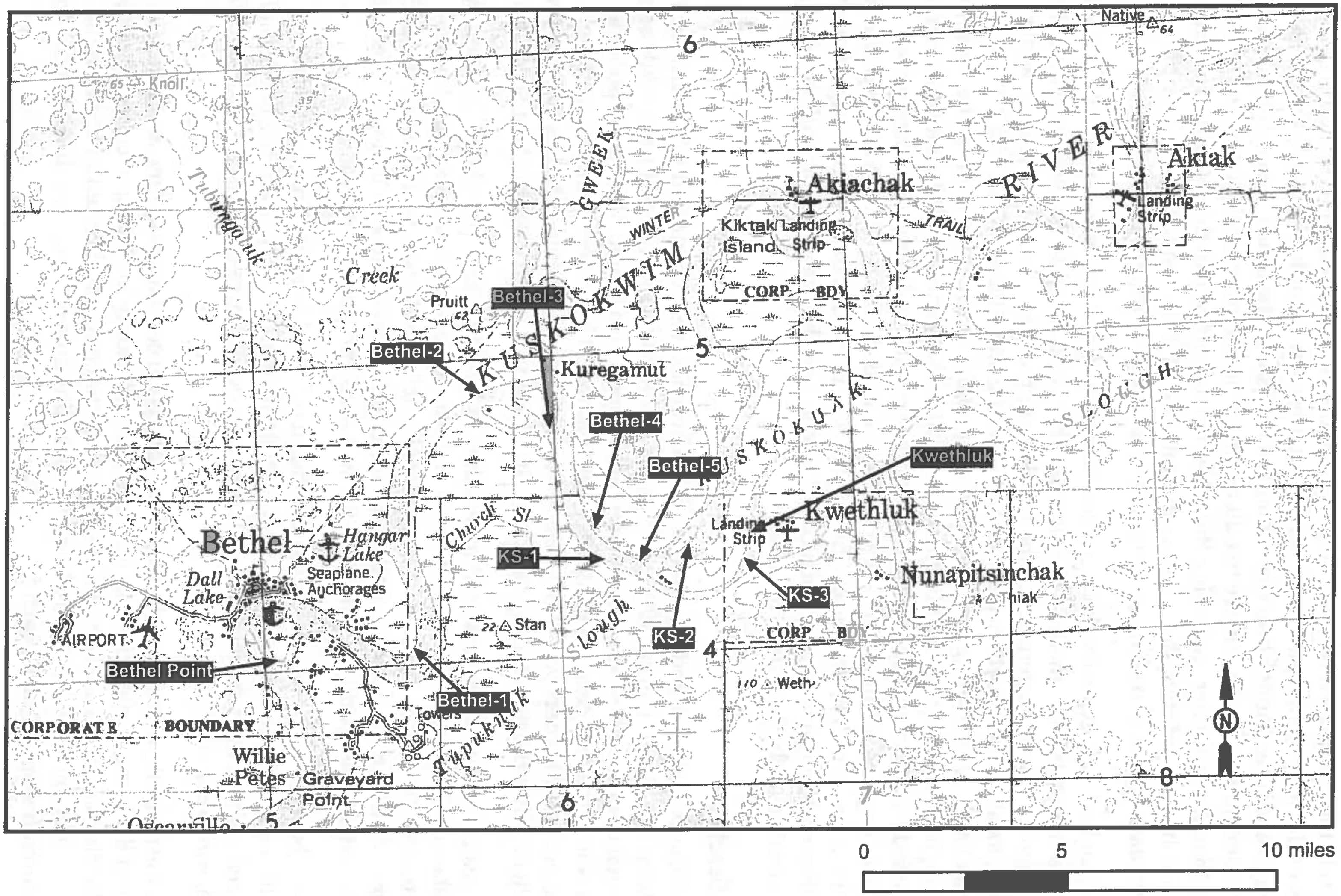
Stranding on Beaches

During 1997-98, surveys for stranded juvenile fish on beaches were conducted while measuring wakes and observing birds. During 1999, surveys for stranded fish were conducted while seining and at occasional opportunities when the hovercraft stopped on a beach. Whenever possible, an area of beach was surveyed (cleared) to identify fish that might have been there prior to the passing of the hovercraft where wake measurements (1997-98) and seining studies (1999) were being conducted. After the hovercraft passed by, the beach was again examined for stranded fish.

During both years, beaches were surveyed by walking at least two lines parallel to the shore for a measured distance. The length of the beach surveyed was dependent upon each site but was typically about 200-300 yards. The lines were approximately 5 feet apart with the first about 5 feet from the water. Additional lines were walked as necessary to cover the area that was affected by the wake. The extent was readily apparent by the wet sand and puddles of water.

During 1997-98, beaches were also checked after staged boat wakes at varying speeds and distances. Although the team focused on the potential for small fish/fry stranding because of reported concerns about their susceptibility, all observed occurrences of stranded fish, regardless of age or size, were recorded.

During 1999, the majority of the stranding observations were conducted as time and conditions allowed around the seining operation. In this study, the stranding information collected at these sites was indicative of worst case conditions since the hovercraft was directed to travel in the shallow water within 50 feet of shore. Additional stranding surveys were conducted occasionally when the hovercraft stopped on a beach.



Fish Stranding and Wake Survey Locations - Part 1

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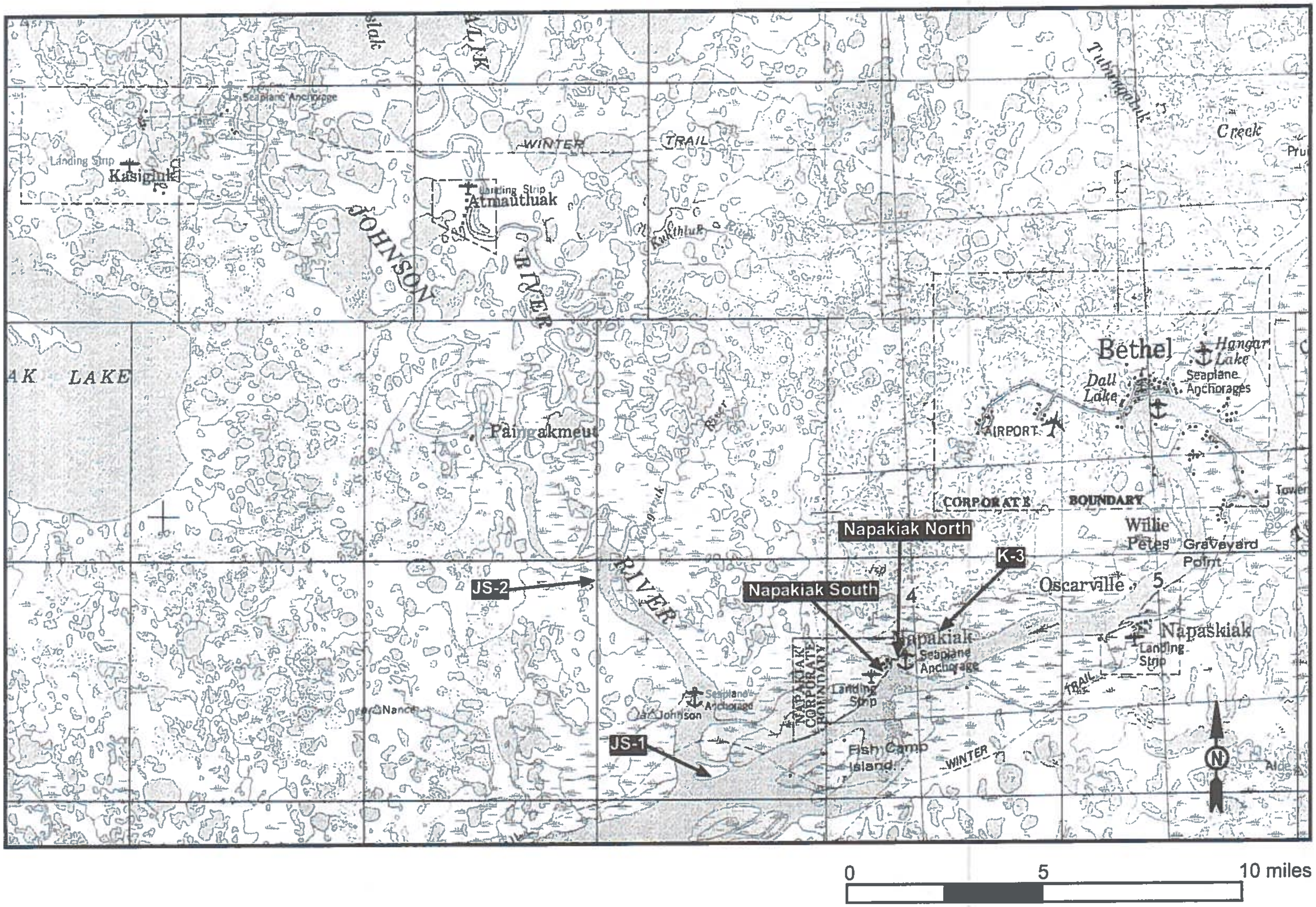
Figure 2.10

UNITED STATES POSTAL SERVICE.



Fish Stranding and Wake Survey Locations - Part 2

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Figure 2.11

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Stranding at Hovercraft Landing Sites

In response to reports that fish were being stranded at the hovercraft landing sites, these locations were checked for stranded fish during July and August 1998 and June, July, and August 1999. The process involved checking the landing area after the hovercraft had docked.

During 1998, only villages with low-gradient beaches at the landing sites were checked (Napakiak, Napaskiak, Kwethluk, Akiachak, and Akiak), whereas all landing areas were observed in 1999. The observer rode in the hovercraft and disembarked immediately upon stopping to begin the survey. There was no opportunity to pre-check beaches before the hovercraft landed; thus, discovered fish could not always be attributed to the hovercraft.

During both years, beaches were surveyed by walking lines parallel to the shore in the areas affected by the hovercraft. The length of the beach surveyed was about 80 yards, if possible. The lines were typically 5 feet apart, with the first about 5 feet from the water. Additional lines were walked parallel to the shore as necessary to cover the area that was affected by the wake. The extent was readily apparent by the wet sand and puddles of water.

2.2.4 Subsistence Fishing

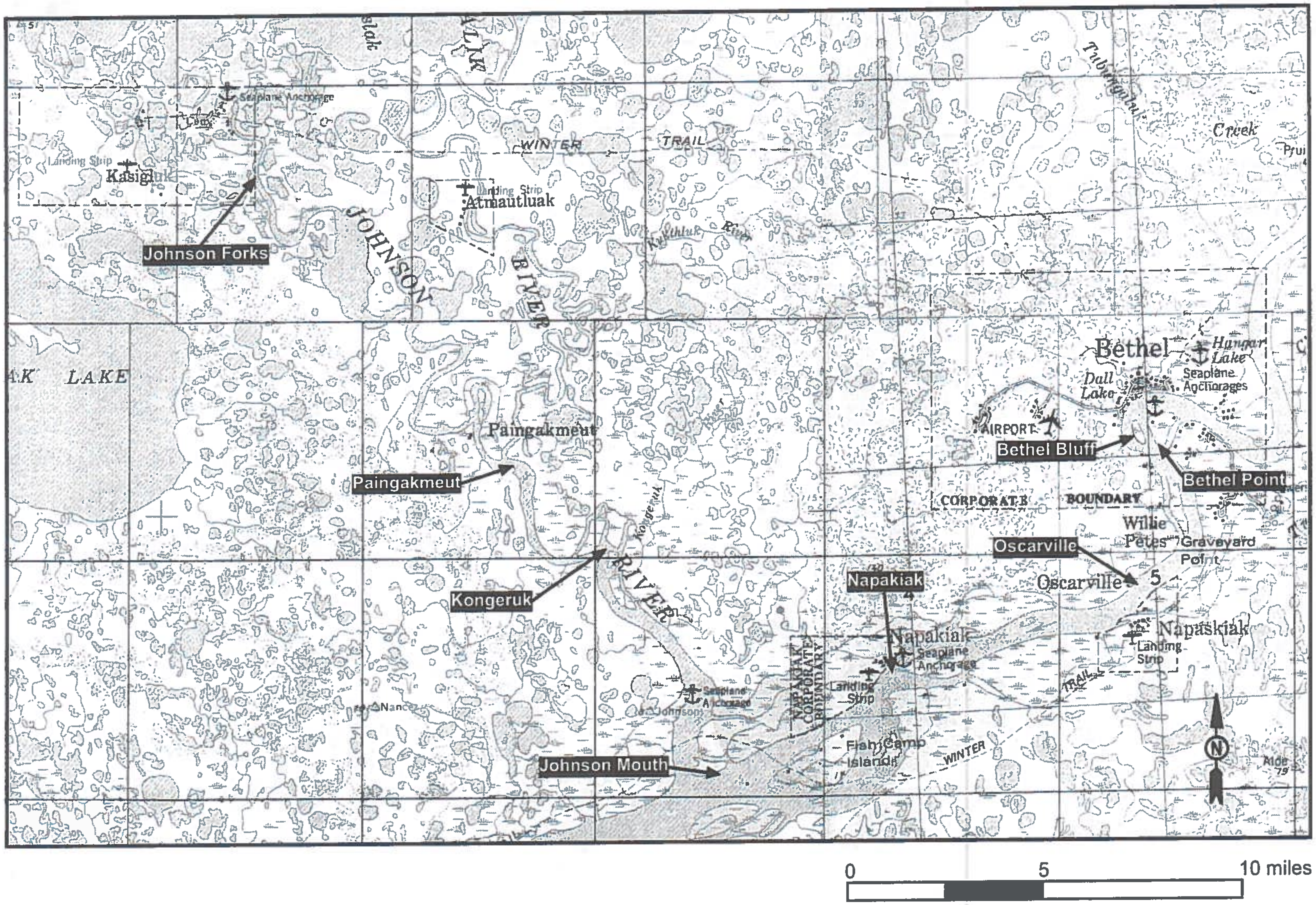
Gillnet Catch

Gillnet fishing on the Kuskokwim and Johnson Rivers is an important means of subsistence fishing for residents. To assess if the hovercraft might be having an effect on subsistence gillnet fishing, the team conducted test fishing studies to discern possible differences in catch rates when the hovercraft travels by a gillnet. Gillnetting locations used in 1998 are shown in Figures 2.12 and 2.13, and locations used in 1999 are shown in Figures 2.14 and 2.15.

The fishing experiment involved using pairs of gillnet sets: test sets (short net sets during which the hovercraft passed by) and control sets (sets of the same duration without the hovercraft passing by)(Figure 2.16). The test and control sets of each paired set were fished in the same location, one immediately after the other. Nets were fished in two ways: set nets, which are anchored in place often with one end attached to shore, and drift nets, which are allowed to drift with the current.

Nets were initially fished for 30 minutes, although this duration varied slightly for each pair, and the duration was decreased to 15 to 20 minutes in latter campaigns to further minimize fish injury. Since the paired net sets were fished for the same duration and were compared only to each other, the changes in duration between different sets of pairs had no influence on the analyses. Test sets were timed so that the hovercraft passed by between 5 and 15 minutes into the set, allowing time for the disturbance from setting the net to cease. Using this paired system, there was no need for net fishing in control areas not accessed by the hovercraft, where additional natural variation (e.g., habitat, fish presence, etc.) might lead to unrelated bias in catch rates. The objective was to evaluate the hovercraft's effects, not fish populations in different areas.

During 1998, the team used set nets for the gillnet fishing experiments. They developed an improved method for the timing of the net setting during the July 1998 session. After deployment, the net was disabled by tying the mesh and lead line to the float line. At the specified time, the net could be enabled (netting dropped into fishing position) within one minute, greatly reducing the



Gillnetting Locations - Part 1(1998)

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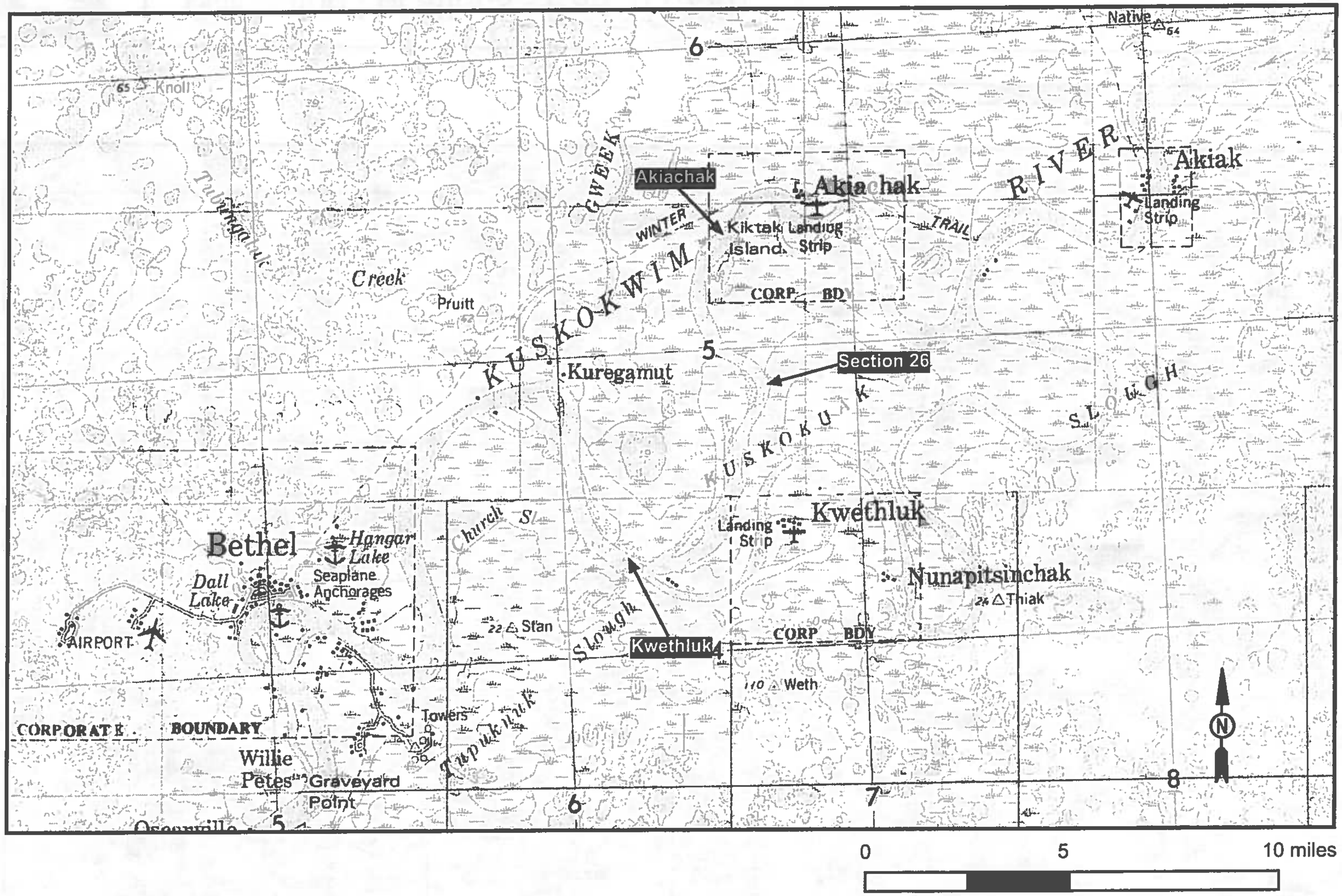
Figure 2.12

UNITED STATES POSTAL SERVICE.



Gillnetting Locations - Part 2 (1998)

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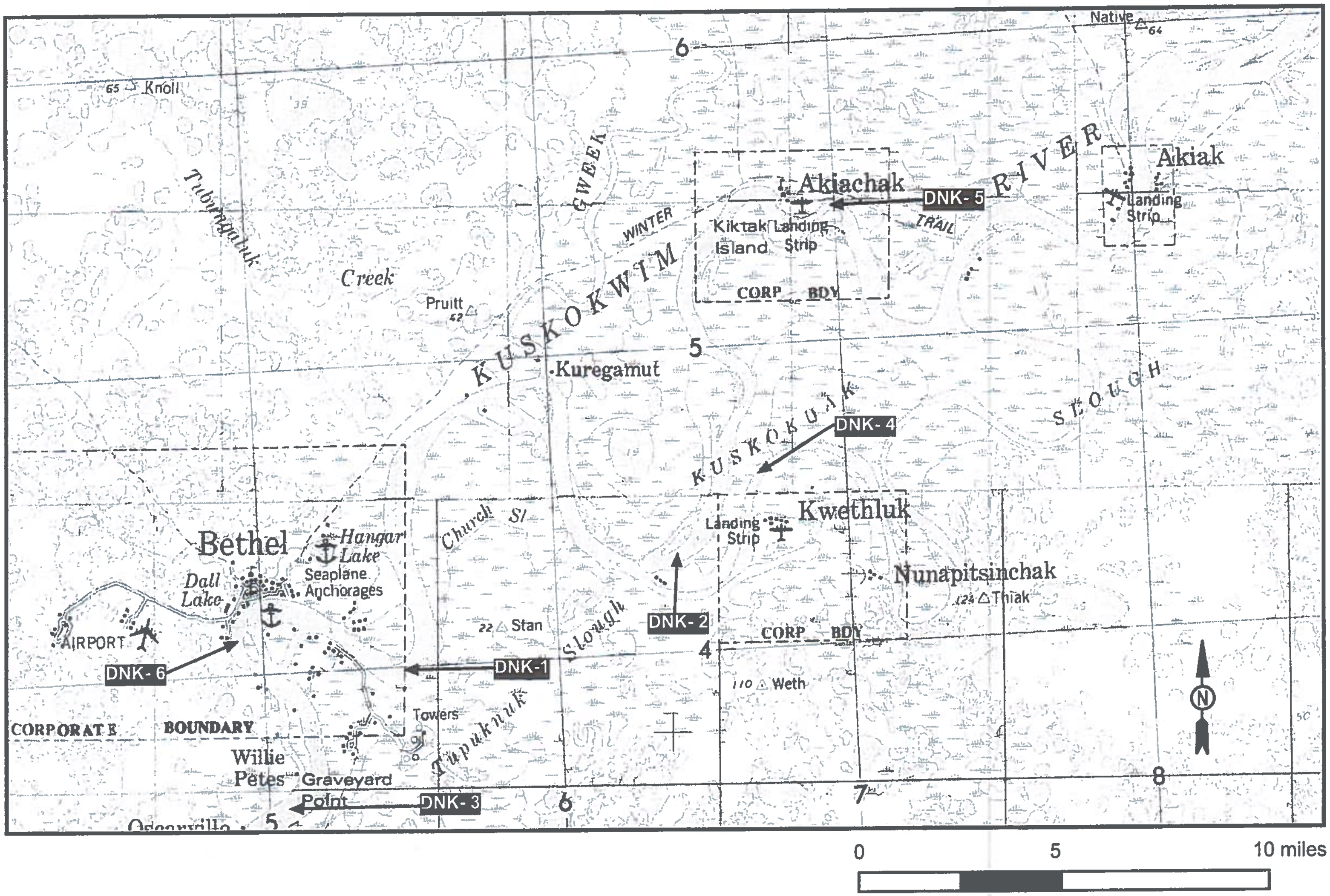
Figure 2.13

UNITED STATES POSTAL SERVICE.



Gillnetting Locations on the Kuskokwim River

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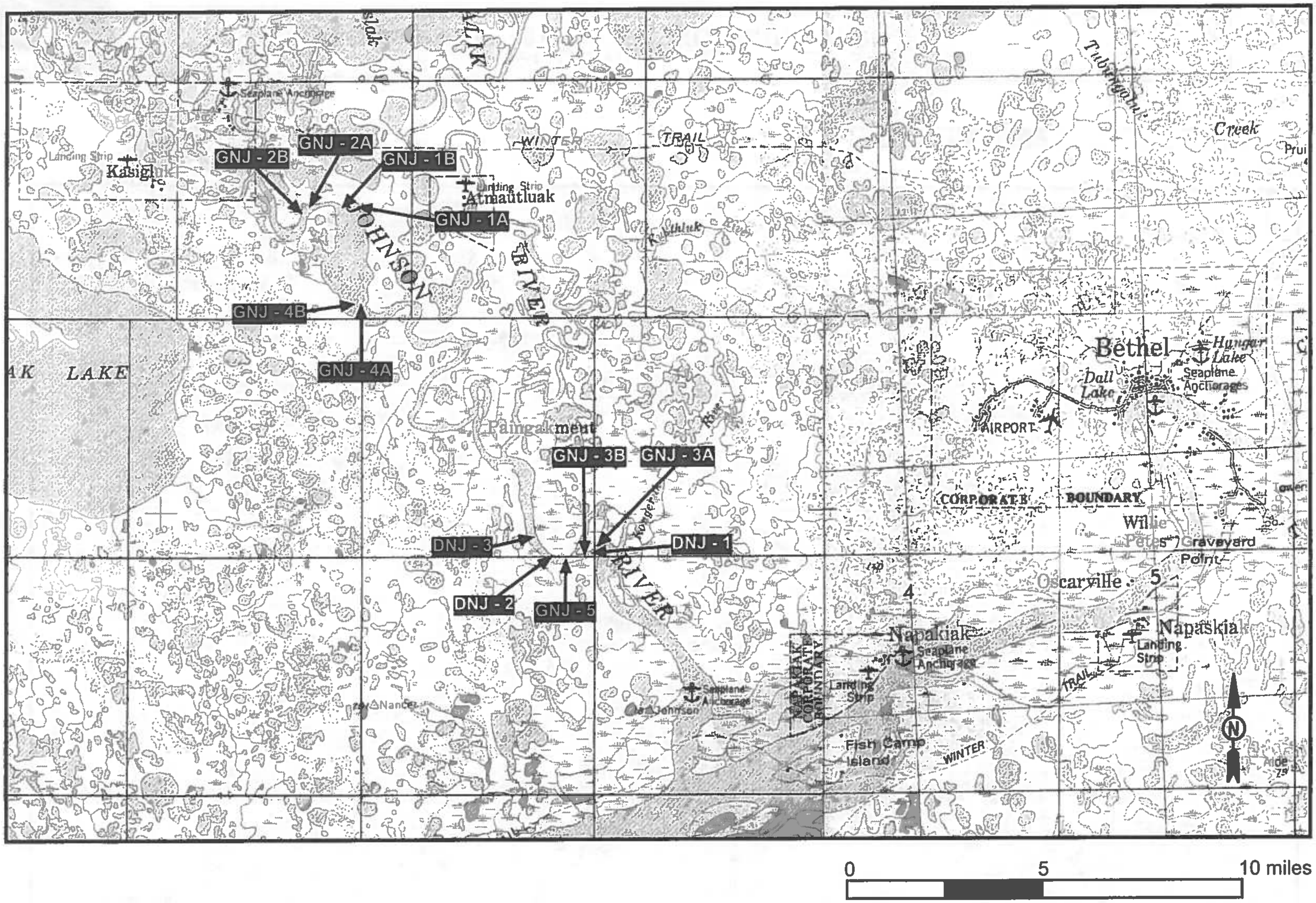
Figure 2.14

UNITED STATES POSTAL SERVICE.



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Gillnetting Locations on the Johnson River (1999)

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Figure 2.15

Hovercraft passing gillnet test

Removing fish from net for release

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Gillnet Fishing

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Figure 2.16

necessary lead-time and uncertainty associated with ensuring that the hovercraft passed by the net during the preferred time period. This practice greatly improved the efficiency of the netting study by reducing the logistical uncertainty and increasing the number of sets deployed.

Many local fishermen use drift nets for subsistence fishing in addition to set nets, and they fish these nets for a much shorter duration, generally less than one hour for each set. Therefore, to improve study efforts, the team used drift nets in 1999 in conducting the paired test fishing experiments. During 1999, only drift nets were used in test fishing for salmon on the Kuskokwim River, whereas a combination of set nets and drift nets were used in the test fishing for whitefish on the Johnson River. Drift nets are fouled less by debris and are easier to fish in areas of high fish numbers than set nets.

Captured fish were identified by species and released. With a maximum time in the net of 30 minutes and minimal handling, mortality was minimal.

Two types of nets were used depending upon the target fish species. Whitefish nets were fished in the Johnson River and occasionally in the Kuskokwim River. The whitefish nets were 60 feet in length, 9 feet in depth, and 4 inches in mesh size. Salmon nets were fished in the Kuskokwim River only. They were 60 feet in length, 21 feet in depth, and 5.5 inches in mesh size. The salmon nets, built by The Donaldson Company in Anchorage, were designated as "Kuskokwim Chum" nets. The color used was "Kuskokwim gray". The 5.5-inch mesh size was selected to produce the best overall catch rate when used for all of the species present in the river. While the mesh size was somewhat small for chinook and large for sockeye, good catches were made of the smaller and larger individuals of these two species, respectively. This mesh size was optimal for coho and chum salmon.

The catch rates of the test and control sets were compared to determine if the hovercraft affected fishing success. Data were statistically analyzed using the Wilcoxon Signed Rank Test to test for significant differences between test and control catch rates. The Wilcoxon Signed Rank Test is a non-parametric test used to analyze paired data. This statistical analysis is explained further in Appendix B.

Winter Blackfish Fishing

In response to concerns raised by Johnson River village residents, monitoring was undertaken during late January 2000 to evaluate the hovercraft's potential effects on Alaska blackfish subsistence fishing on the Johnson River.

The only hovercraft-related activity that could affect the blackfish fishery is physical disturbance. There was concern that the noise, currents, displacement, etc., produced near the fishing areas might scare blackfish away, thereby reducing the overall number of blackfish available for harvest. Similarly, the disturbance might be affecting fishing success by causing the blackfish to stay away from the fishing holes, rather than congregating in the holes. Thus the purpose of this monitoring was to determine if hovercraft operations drive fish away from traps or alter behavior such that the fish are less likely to enter the traps.

The monitoring consisted of two components: an investigation into underwater sound produced by the hovercraft and the potential implications of this sound on blackfish behavior and an investigation into blackfish behavior in response to the hovercraft as it travels over the ice of the Johnson River. First hand observations of the fishing area and methods employed by residents of the tundra villages were conducted and behavioral observations of blackfish were made using an underwater viewing system.

Methodology for Blackfish Observations

Observations of winter subsistence fishing for blackfish were conducted from January 24 to January 29, 2000 near the villages of Kasigluk and Nunapitchuk. The hovercraft route along the Johnson River from each village down to Lake Nunavarq was surveyed for blackfish fishing locations.

Fishermen encountered on the river were interviewed to determine current and past fishing success, fishing locations, and fishing methods. A fishing location where blackfish were abundant and being harvested regularly was selected to conduct underwater observations of blackfish behavior in response to the hovercraft and other traffic on the river. The location selected was next to the main boat landing / winter road to the new part of the village of Kasigluk, located on the west side of the river. Permission to conduct these observations was obtained from the fisherman who "owned" the fishing hole. The blackfish catch was recorded on each day.

The underwater observations were conducted using an Aqua-Vu® underwater viewing system equipped with infrared lights (Nature Vision, Inc.). The video output from the underwater camera was recorded on an 8mm video recorder. The underwater camera was positioned approximately 10-12 inches under the surface of the water in the fishing hole and approximately 12 inches from the blackfish trap (Figure 2.17). This positioning allowed simultaneous viewing of the top (mouth) of the blackfish trap and the upper 1-foot of the water column, where the majority of the fish were congregating. Observations of general blackfish behavior were recorded prior to the hovercraft's arrival for approximately 2 hours on each day that the hovercraft was traveling to the Johnson River villages. On two days, January 25 and 28, the hovercraft was directed to make several passes by the fishing hole at varying distances. The behavior of the fish in reaction to these passes was recorded on videotape. The time of each pass was recorded in a field logbook and the corresponding tape counter reading on the video recorder was also recorded when possible. Observations of water level changes and the reactions of fish that were visible in the hole were also recorded when possible. The videotapes of the blackfish behavior were viewed later to determine if a reaction was apparent, and if so, the duration of any reaction. This determination was based on observations of the immediate behavior of blackfish as the hovercraft approached and passed by and subsequent behavior following passage of the hovercraft.

Underwater Sound Measurements

A team from the Volpe National Transportation Systems Center, Acoustics Facility, conducted underwater sound measurements.. The objectives of the underwater sound monitoring program were to quantify underwater sound levels emanating from the hovercraft for use in determining any potential effect on blackfish, and to determine relative differences between hovercraft underwater sound levels and those of other transportation noise sources.

The instrumentation used in the underwater measurements is described in detail in the *Draft Hovercraft Underwater Noise Measurements in Alaska,* (USPS, 2000). Underwater measurements were made by placing a hydrophone in the water, either 1.5 or 5 feet beneath the ice and snow line. Underwater sound measurements were recorded at two locations; one on the Kuskokwim River in Bethel and the other adjacent to fishing hole used for the underwater blackfish observations, on the Johnson River at Kasigluk.

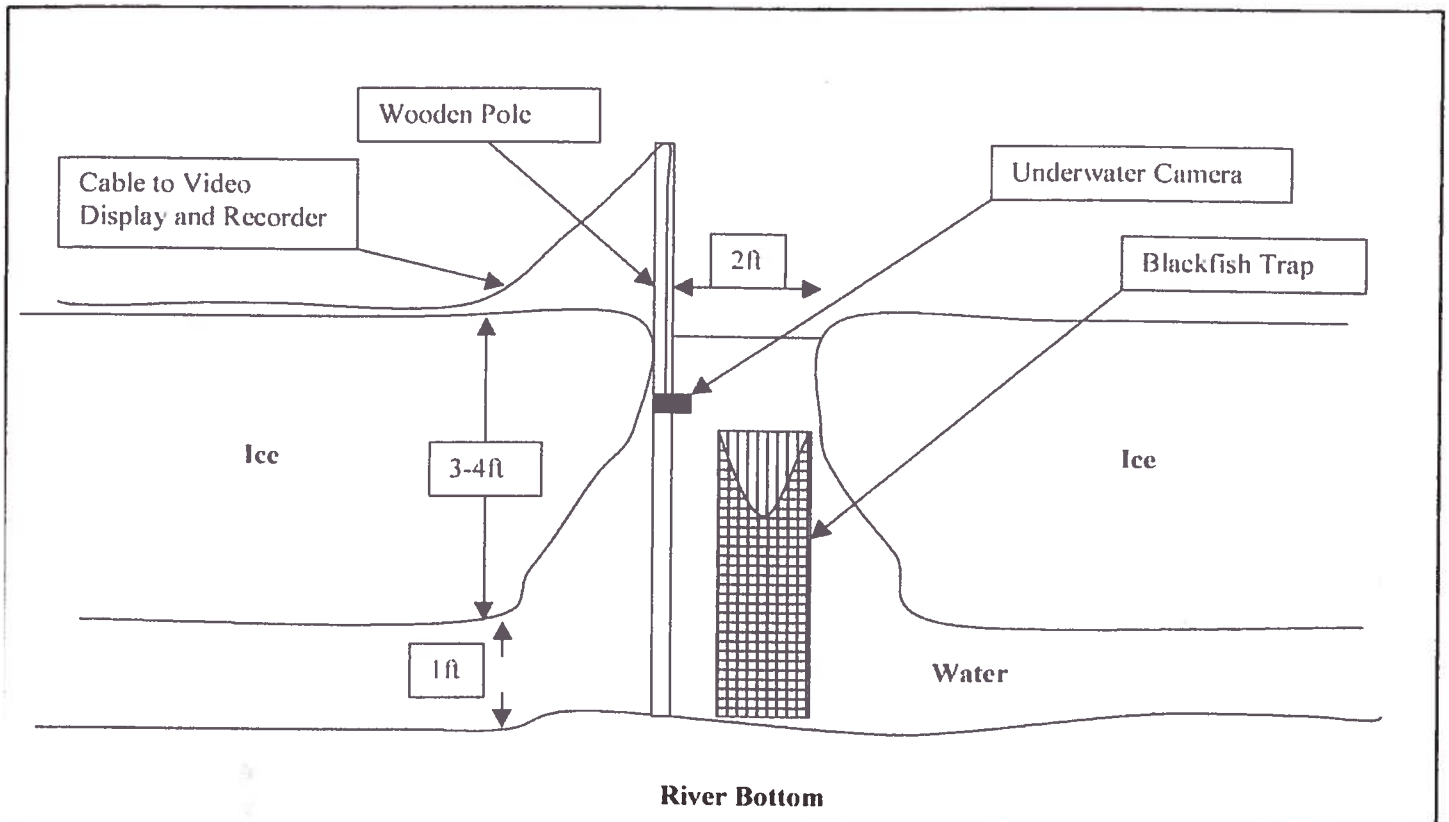

Diagram and Picture of the Underwater Camera Setup

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Figure 2.17

3.0 Results and Discussion

3.1 Waterfowl Resources

The monitoring for potential effects on bird resources along hovercraft routes consisted of a combination of monitoring for evidence of direct behavioral effects, as evidenced by flushing reactions of birds in relation to the hovercraft; monitoring of waterfowl abundance along the rivers where the hovercraft operates; and monitoring of waterfowl abundance in areas adjacent to the rivers.

3.1.1 Flushing of Waterfowl

The behavioral observations of flushing reactions consisted of two components: flushing observations from moving watercraft and flushing observations from stationary locations.

Flushing Observations Made from Moving Watercraft

Flushing responses of waterfowl were observed in each of the first four monitoring campaigns (1997-1998). Flushing observations were not continued during the 1999 monitoring campaigns because it was determined that waterfowl species nearly always flush in response to the hovercraft. During this study, 9,955 birds were observed to determine their reaction to the hovercraft.

Flocks and individual numbers of gull species far outnumbered other species observed on both rivers (Tables 3.1 and 3.2). Gulls flushed about half of the time on both the Kuskokwim (52.5 percent) and Johnson Rivers (42.5 percent) in response to the hovercraft, as compared to less than 8 percent in response to motorboats. This pattern was not, however, evident for duck and geese (hunted species) which nearly always flushed (63.9 to 100 percent) in response to either craft (Tables 3.1 and 3.2).

A notable observation is that, based upon a very limited amount of data, bald eagles are relatively tolerant of both types of craft. Of 7 bald eagles observed from the hovercraft, only one bird flushed (14.3 percent). Similarly, of the 11 bald eagles observed from the motorboat only 2 flushed (18.2 percent).

It is important to note that gulls, ducks, and shorebirds that flushed from the hovercraft and motorboats were sometimes observed landing in nearby habitats after only flying a short distance. The actual frequency at which this occurred could not be measured from either craft because some birds were often too quickly out of sight of the observers. Due to the curves in the Johnson River (allowing visibility behind the boat), ducks were sometimes seen landing in the marshes bordering the Johnson River after flushing from the river. Flushed shorebirds were occasionally observed landing back down on the beach immediately after the hovercraft passed.

The evaluation of flushing distance was focused only on birds that were not directly ahead of the craft, because it was assumed that birds directly in front had to flush to avoid the craft. Birds along the side of the path of the crafts did not have to flush to avoid the craft and therefore offer a

Table 3.1 Comparison of Number of Birds Flushed by Hovercraft and Motorboat (Kuskokwim River), 1997-1998

	# of flocks	Mean # birds/flock	Total # birds	Mean # birds flushed	# birds flushed	% flushed
Hovercraft						
Arctic Tern	23	1.96	45	1.96	45	100.0
Bald eagle	6	1.17	7	0.17	1	14.3
Common raven	33	2.73	90	1.15	38	42.2
Duck (all spp.)	87	4.99	434	4.93	429	98.8
Goose (all spp.)	12	13.00	156	12.42	149	95.5
Gull (all spp.)	368	4.25	1,565	2.23	821	52.5
Hawk (all spp.)	1	1.00	1	0.00	0	0.0
Shorebird (all spp.)	56	6.18	346	5.32	298	86.1
Other	2	3.00	6	0.00	0	0.0
Total	**588**	**4.51**	**2,650**	**3.03**	**1781**	**67.2**
Motorboat						
Arctic Tern	2	1.00	2	0.50	1	50.0
Bald eagle	9	1.22	11	0.20	2	18.2
Common raven	37	2.16	80	0.19	7	8.8
Duck (all spp.)	54	4.13	223	3.91	211	94.6
Goose (all spp.)	7	27.71	194	17.71	124	63.9
Gull (all spp.)	325	4.81	1,562	0.32	104	6.7
Hawk (all spp.)	1	1.00	1	0.00	0	0.0
Shorebird (all spp.)	3	1.667	5	0.00	0	0.0
Other	3	1.00	3	0.67	2	66.7
Total	**441**	**4.72**	**2,081**	**1.02**	**451**	**21.7**

Table 3.2 Comparison of Number of Birds Flushed by Hovercraft and Motorboat (Johnson River), 1997-1998

	# of flocks	Mean # birds/flock	Total # birds	Mean # birds flushed	# birds flushed	% flushed
Hovercraft						
Arctic Tern	34	1.91	65	1.68	57	87.7
Bald eagle	1	2.00	2	0.00	0	0.0
Common raven	11	1.73	19	1.09	12	63.2
Duck (all spp.)	544	2.96	1,609	2.70	1,468	91.2
Goose (all spp.)	16	8.50	136	8.06	129	94.9
Gull (all spp.)	235	4.40	1,035	1.87	440	42.5
Hawk (all spp.)	6	1.00	6	0.50	3	50.0
Sandhill crane	7	1.86	13	1.71	12	92.3
Shorebird (all spp.)	54	3.33	180	3.17	171	95.0
Tundra swan	6	1.50	9	1.50	9	100.0
Other	10	1.7	17	0.47	8	47.1
Total	**924**	**3.35**	**3,091**	**2.50**	**2,309**	**74.7**
Motorboat						
Arctic Tern	14	1.07	15	0.29	4	26.7
Bald Eagle??	0	0	0	0	0	0
Common raven	4	1.75	7	0.25	1	14.3
Duck (all spp.)	157	4.87	764	3.80	596	78.0
Goose (all spp.)	1	3.00	3	3.00	3	100.0
Gull (all spp.)	185	3.63	672	0.28	51	7.6
Hawk (all spp.)	1	1.00	1	0.00	0	0.0
Sandhill crane	2	2.00	4	1.00	2	50.0
Shorebird (all spp.)	20	2.80	56	1.95	39	69.6
Tundra swan	2	1.50	3	0.50	1	33.3
Other	4	2.0	8	0.75	6	75.0
Total	**390**	**3.93**	**1,533**	**1.80**	**703**	**45.9**

better discrimination between response (flush or not flush) to the hovercraft versus motorboat. Waterfowl almost always flushed for either craft, again eliminating the ability to discriminate between a response (flush or not) to the different crafts.

Due to the methods used, the flushing data collected have some inherent biases that require discussion to interpret the data. The data are biased toward larger birds and toward birds that flush more readily. Furthermore, birds that hid rather than flushed may not have been recorded as not flushing simply because the observer could not spot them. Similarly, small birds or birds hidden along the shore were not likely observed before they flushed. Small birds could also be missed after they flushed if they were not at close range. However, most of these biases would be the same for both the hovercraft and motorboats. Due to the better viewing perspective from the hovercraft (higher above the water), the data from this craft might be biased toward more observations of birds, hiding or flushed. Furthermore, more miles of river were observed from the hovercraft as a result of days when the motorboats could not operate. Standardization by time of monitoring is not possible because different speeds of travel result in different amounts of river coverage for the same amount of elapsed time. Similarly, standardization by the distance traveled is not possible because the river distance varied for each effort (for both craft) as the crafts took slightly different routes depending upon tide and weather conditions.

Because of these biases, it is important not to compare raw numbers in the data. The proportion of birds observed that flushed, however, should be comparable, as that parameter, although sensitive to viewing bias, is not sensitive to sampling effort. The remaining bias that more birds would be observed in general due to the better perspective of the hovercraft cannot be removed, but its impact on the data would likely be to increase observations of flushed birds from the hovercraft and provides a conservative measure of bird flushing effects.

Flushing Observations Made from Stationary Locations

Stationary observers recorded the effects of the hovercraft and other river craft on the behavior of various birds when measuring wakes and checking for stranded fish during the 1997 and 1998 monitoring efforts. The beaches used for stranding studies were usually not being used by birds at the time of observations. Below is a summary of stationary observations when birds were present.

At station KS-1 (Figure 2.10), 4 gulls, 3 arctic terns, and 3 shorebirds were using the beach. None of the birds flushed when a motorboat passed about 1,500 feet out into the river. Shortly thereafter, the birds also did not flush when the hovercraft passed by, also roughly 1,500 feet out into the river. At station KS-2 (Figure 2.10), 2 Canada geese, 1 black turnstone, 5 semi-palmated plovers, and 2 gulls were using the beach when a motorboat approached. The geese flushed before the boat was within 1,000 feet of the beach and left the area. In contrast, the other birds did not flush when the boat passed within 300 feet of the shore. Later, at the same beach, 4 ducks, 2 black turnstones, and 20 shorebirds were present when the hovercraft passed by. The ducks flushed and left the area when the hovercraft was between 100 and 500 feet in the distance. Although the black turnstones and shorebirds flushed when the hovercraft was 100 to 300 feet away, they circled and landed immediately nearby.

These limited observations corroborate the observations and results made while observing flushing from the hovercraft. Those results suggest that waterfowl are more wary than many other birds and that shorebirds will often land nearby after the disturbance passes, regardless of whether the disturbance is by a motorboat or hovercraft.

3.1.2 Waterfowl Use of River Habitat

The object of the 1999 waterfowl monitoring was to determine whether the hovercraft disturbs waterfowl species to the extent that the waterfowl might significantly alter their use of habitats along the rivers traveled by the hovercraft. Unlike in 1997-1998, no attempt was made to record non-waterfowl species in 1999. Each of the five river transects used for waterfowl observations was surveyed either 15 or 16 times during the 1999 monitoring, resulting 1,311 waterfowl being observed. The discussion of these results is presented separately for the Kuskokwim and Johnson rivers. A complete list of the waterfowl survey data is presented in Appendix F.

A total of 292 ducks were observed on the transect within the hovercraft route on the Kuskokwim River (Table 3.3). A total of 69 ducks were observed along the transect on the Gweek River, and 400 ducks were observed along the transect on the slough off the Kuskokwim River. The Gweek River and Kuskokwim Slough transects were used as a control for comparisons of waterfowl abundance on the transect within the hovercraft route on the Kuskokwim River. These data were standardized by unit length of transect to yield 4.3 waterfowl per mile on the Kuskokwim River, 2.4 waterfowl per mile on the Gweek River, and 22.2 waterfowl per mile on the slough off the Kuskokwim River. Statistical evaluation of these data revealed significant differences among the waterfowl counts observed, with the slough off the Kuskokwim River having significantly higher waterfowl abundance than both the Kuskokwim and Gweek Rivers (Table 3.3). Waterfowl abundance on the Kuskokwim and Gweek Rivers was not significantly different.

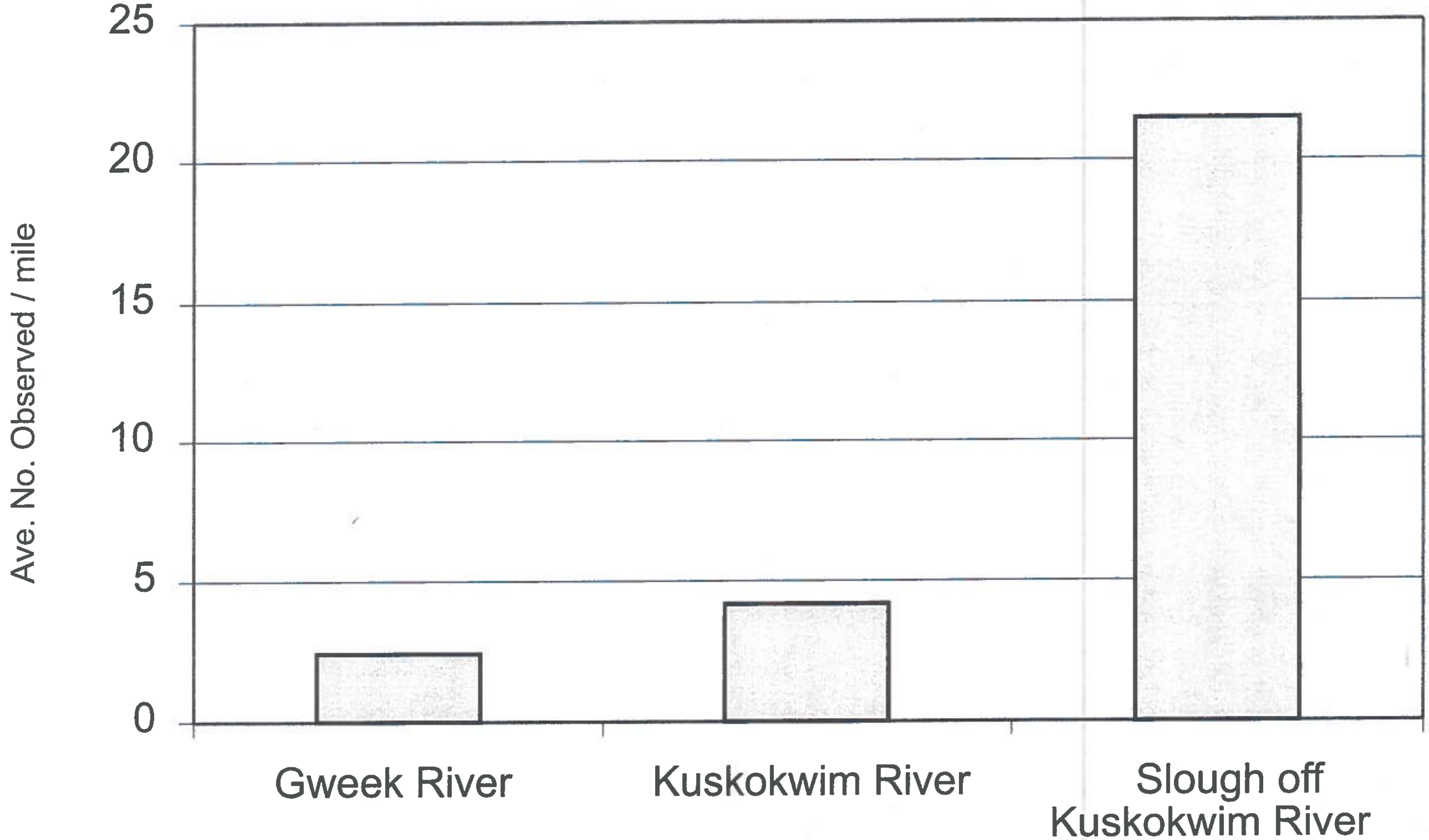
Table 3.3 Comparison of Waterfowl Abundance along Kuskokwim River with Control Areas (Gweek and Slough)

	Kuskokwim River	Gweek River	Slough off Kuskokwim River
Total No. Waterfowl Observed	292	69	400
Average No. Waterfowl Observed per Survey	18.3	4.6	26.7
Transect Length (miles)	4.3	1.9	1.2
Average No. Observed / mile of Transect	4.3	2.4	22.2
Statistical Comparison	**P<0.05**		
Kuskokwim vs. Gweek	No		
Kuskokwim vs. Slough	Yes		
Gweek vs. Slough	Yes		

Notes: Statistical comparison performed using Kruskal-Wallis one-way ANOVA on ranks with Dunn's pairwise multiple comparisons.

Waterfowl use of the Kuskokwim River and the Gweek River was significantly less than waterfowl use on the slough, but use of the Kuskokwim River and Gweek River was not different (Figure 3.1). Since the Kuskokwim River has more boat traffic than the Gweek, fewer waterfowl might have been expected to use the Kuskokwim River. These observations suggest that other factors, such as habitat quality, are having a greater effect on waterfowl use, rather than disturbance from motorboats or the hovercraft.

A total of 447 waterfowl, including 300 ducks, 146 geese, and 1 swan, were observed along the transect within the hovercraft route on the Johnson River (Table 3.4). A total of 103 waterfowl,



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Comparison Of Waterfowl Abundance Along Hovercraft Route On Kuskokwim River With Control Areas

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Figure 3.1

including 99 ducks, 3 geese, and 1 swan, were observed along the transect on the Pikmiktalik River, which was used as a reference location for the Johnson River. These data were standardized by unit length of transect to yield 1.2 waterfowl per mile on the Johnson River and 0.6 waterfowl per mile on the Pikmiktalik River (Figure 3.2). Statistical comparison of these data showed a significant difference in waterfowl abundance between these transects ($P<0.05$; Table 4), indicating that waterfowl were more abundant on the Johnson River during these surveys, than on the Pikmiktalik River. These results indicate that the hovercraft is not having an effect on waterfowl use on the Johnson River.

Table 3.4 Comparison of Waterfowl Abundance along Johnson River with Reference Area (Pikmiktalik).

	Johnson River	Pikmiktalik River
Total No. Waterfowl Observed	447	103
Average No. Waterfowl Observed per Survey	27.9	6.4
Transect Length (miles)	9.2	4.7
Average No. Observed / mile of Transect	1.2	0.6
Statistical Comparison	**p = 0.004**	

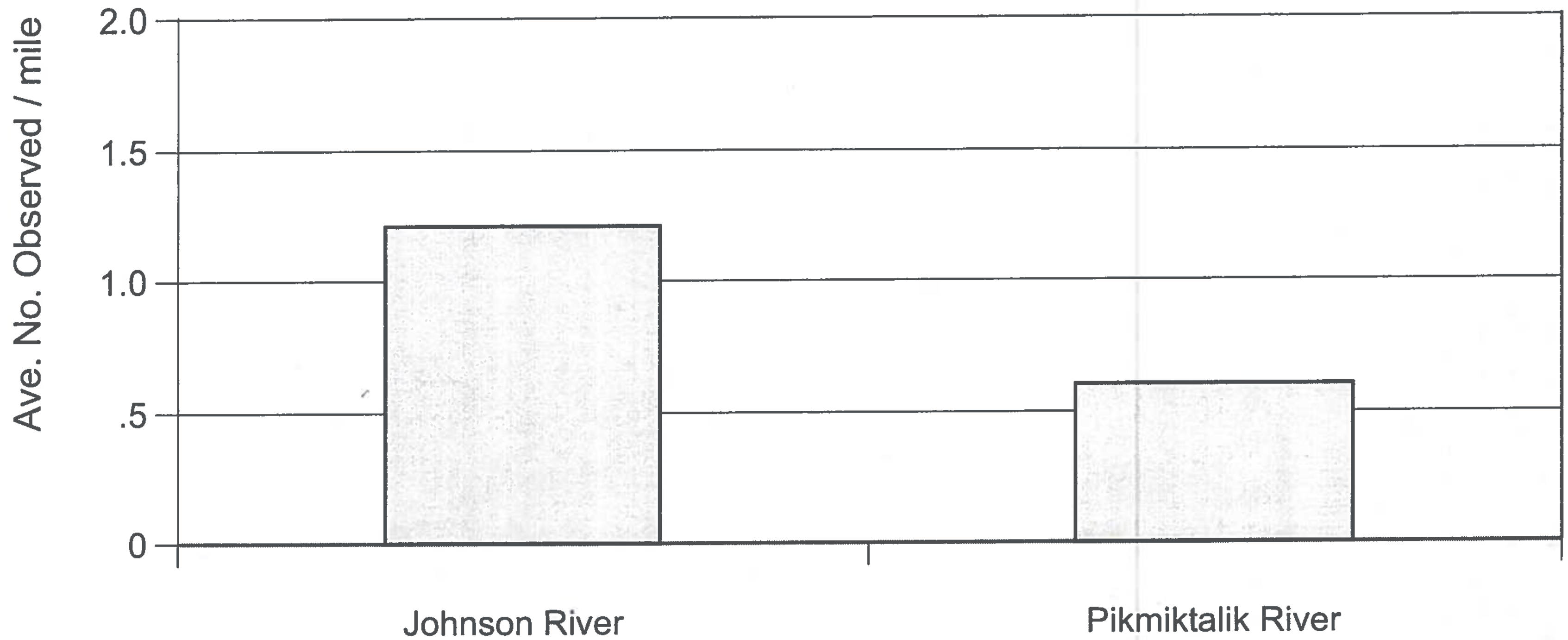
Notes: Statistical comparison performed using Mann-Whitney Rank Sum Test.

3.1.3 Breeding Waterfowl

Daily aerial surveys for breeding waterfowl and general waterfowl use of habitats on and near the rivers were conducted during one campaign in 1998 (May) and three campaigns in 1999 (June, July, August), during which 4,865 waterfowl were observed. To aid interpretation of the survey results, the Kuskokwim River and Tundra River results are presented separately below. Data from all the waterfowl aerial surveys are combined within these two areas to present an overall picture of waterfowl use. The results of the 1999 habitat surveys are presented within the discussion of each river area, in order that potential habitat bias is understood. The discussion of the waterfowl observations follows the presentation of the habitat surveys for each river.

As noted, a concern exists that the hovercraft could adversely affect hunting success in two ways – by simply chasing the birds from the area or by disturbing breeding waterfowl, which in turn would affect the numbers of waterfowl available to hunters. These two phenomena are interrelated and thus can be assessed together by evaluating the effect or lack of effect the hovercraft has on the distribution of waterfowl along its operational routes. An observed difference between river areas and off-river areas within the operational area or reduced use between the operational areas and control areas would suggest an effect. Conversely, lack of differences between these areas would be evidence that the hovercraft is not affecting breeding waterfowl, waterfowl distribution, and thus subsistence hunting of waterfowl.

The data collected from the aerial surveys cannot be used as population estimates but can be used as an indicator of breeding waterfowl and general waterfowl use of different areas. Data from May, June, and July surveys would respectively serve as indicators of relative breeding, brooding, and rearing waterfowl activity. Similarly, the August survey would represent the resident ducks



Comparison Of Waterfowl Abundance Along Hovercraft Route On Johnson River With Control Areas

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Figure 3.2

(including young of the year) augmented by some early migrants. Thus these data can be used as an index of relative recruitment to the areas and, consequently, a relative index of waterfowl available to hunters. Since methodologies were the same for all areas surveyed, the data are comparable across the areas and were combined for analysis.

Kuskokwim River

In August 1999, habitats of the seven operational area and six control area transects on the Kuskokwim River were recorded from a helicopter using a video camera. The video tapes were analyzed later to determine the proportions of habitat types among the transects. General habitats were similar between control and hovercraft operational areas (Table 3.5). Although the proportion of open water (river/lake) habitat in the control transects was statistically greater than the transects in the hovercraft operational area on the Kuskokwim River ($p<0.05$; Table 3.5), the difference is partially offset by increased amounts of marsh and stream/slough/mudflat habitat that would also support waterfowl. Furthermore, since the amounts of each of the three zones of habitats (river, adjacent, non-river) were specifically measured and used to standardize the waterfowl counts per unit length of habitat zone, the subtle differences in overall habitat should not bias the results.

A total of 809 waterfowl were observed along the seven operational area transects across the Kuskokwim River during the 1999 aerial surveys, and a total of 1,539 waterfowl were observed along the six control transects (upstream of Akiak) (Table 3.6). A total of 132 waterfowl were observed directly on the Kuskokwim River (river zone).

The 1998 off-river data are presented separately from the 1999 data because in 1998 the adjacent zone (<200 yards) was included in the off-river zone. In 1998, 393 waterfowl were observed in the control and 265 were observed in the operational area off-river zones. In 1999, 42 waterfowl were counted in the control area and 123 were counted in the operational area adjacent zones, whereas 316 were observed in the control and 289 in the operational area off-river zones.

Despite no significant differences in habitats between the transects, standardizing for the amount of habitat zone in each transect (as opposed to general habitat types) reduced uncertainty in the results. The general distribution of numbers of waterfowl observed in the river zone were statistically similar (Table 3.7). The difference in the average numbers observed between the control and operational area river zones were a direct result of a large number of ducks and swans that were consistently observed in June and July on an island in Transect C-3 and do not reflect the entire distribution along the areas. The island appeared to provide uniquely high quality habitat as its horseshoe shape protected the birds from the river and the center area provided large amounts of shallow water for feeding.

Similar to the river zones, the adjacent zone and off-river zones showed no statistical difference in waterfowl distribution between the control and operational area transects. This suggests waterfowl in similar amounts were using these areas. Indeed, the averages of waterfowl observed per mile are also similar between hovercraft operational areas and control areas. These results suggest that waterfowl use the river, adjacent, and off-river zones similarly between both hovercraft operational and control areas (Figure 3.3). Thus, it can be concluded that the hovercraft is not affecting the distribution of breeding waterfowl and general waterfowl use of the Kuskokwim River.

Table 3.5 Percent Habitat Type Comparison for Aerial Waterfowl Survey Transects on the Kuskokwim River

Transect	Marsh	Forest	Unforested upland/tundra	River/lake	Stream/pond slough/mudflat
Control for Kuskokwim River (upstream of Akiak)					
C-1	0.0	47.8	21.3	27.9	2.9
C-2	5.4	56.6	0.0	34.1	3.9
C-3	0.0	47.2	8.5	36.9	7.4
C-4	2.5	45.0	14.2	34.2	4.2
C-5	2.7	48.6	15.3	28.8	4.5
C-6	1.5	51.1	16.0	29.0	2.3
Average	**2.0**	**49.4**	**12.6**	**31.8**	**4.2**
Kuskokwim River					
K-1	3.1	46.5	26.8	20.5	3.1
K-2	14.4	51.2	25.6	8.0	0.8
K-3	7.0	66.7	10.9	15.5	0.0
K-4	2.4	32.3	32.3	28.3	4.7
K-5	0.7	51.4	19.0	27.5	1.4
K-6	11.5	37.7	23.0	15.6	12.3
K-7	0.0	33.9	25.0	27.7	13.4
Average	**6.0**	**45.5**	**22.6**	**20.4**	**5.4**
Mann-Whitney Rank Sum Test					
P-value	0.295	0.628	0.022	0.002	0.836

Table 3.6 Waterfowl Observations Along Aerial Transects Across the Kuskokwim River

Transect	Transect Length (miles)	Total No. Waterfowl Observed on Transect [1]	No. Waterfowl observed on river [1]	No. Waterfowl observed <200 yards from river[2]	No. Waterfowl observed >200 yards from river [2]	No. Waterfowl observed off-river, May 1998[3]
Control Transects						
C1	2.5	227	0	1	62	164
C2	2.5	145	94	3	19	29
C3	2.5	690	620	10	12	48
C4	2.5	218	54	19	43	102
C5	2.5	177	17	0	136	24
C6	2.5	82	3	9	44	26
Totals		1539	788	42	316	393
Hovercraft Operational Area Transects						
K-1	2.5	89	33	4	17	35
K-2	2.5	254	6	9	80	159
K-3	2.5	140	47	42	38	13
K-4	2.5	109	27	6	58	18
K-5	2.5	65	9	4	34	18
K-6	2.5	75	2	35	29	9
K-7	2.5	77	8	23	33	13
Totals		809	132	123	289	265

Notes:
[1] These data include waterfowl counts from May 1998 and June, July, and August 1999.
[2] These data include only waterfowl counts from 1999.
[3] Waterfowl counts in May 1998 did not include <200 yard category; only on and off the river counts were recorded.

Table 3.7 Standardized Waterfowl Counts along Aerial Transects across the Kuskokwim River

Transect	River Habitat (miles)	Habitat <200 yards from River (miles)	Habitat off the River (miles)	No. Waterfowl/mile of Transect	No. Waterfowl per mile of River Habitat [1]	No. Waterfowl per mile of Habitat <200 yards from River [2]	No. Waterfowl per mile of Habitat >200 yards from River [2]	No. Waterfowl per mile of Habitat off the River (May 1998)[3]
Control Transects								
C1	0.7	0.2	1.6	35.5	0.0	1.8	15.4	40.6
C2	0.9	0.2	1.4	22.7	43.1	5.2	5.2	7.9
C3	0.9	0.3	1.3	108.1	284.1	11.6	3.6	14.3
C4	0.9	0.2	1.4	34.1	24.7	33	11.8	28.1
C5	0.6	0.7	1.3	27.7	11.8	0.0	67.4	7.4
C6	0.7	0.2	1.6	12.8	1.7	15.6	10.9	6.5
Average	**0.8**	**0.3**	**1.4**	**40.15**	**60.9**	**11.2**	**19.0**	**17.5**
Hovercraft Operational Area								
K-1	0.5	0.4	1.6	13.9	26.2	3.6	4.3	8.7
K-2	0.2	0.2	2.1	39.7	11.8	15.6	15.1	29.9
K-3	0.3	0.2	1.9	21.9	55.8	72.9	7.6	2.6
K-4	0.7	0.2	1.6	17.1	14.9	10.4	14.4	4.5
K-5	0.7	0.5	1.4	10.2	5.1	3.5	9.8	5.2
K-6	0.4	0.5	1.7	11.8	2	30.4	6.8	2.1
K-7	0.7	0.5	1.4	12.1	4.5	19.9	9.5	3.8
Average	**0.5**	**0.4**	**1.7**	**18.1**	**17.2**	**22.3**	**9.6**	**8.1**
Mann-Whitney Rank Sum Test								
P-value					0.95	0.37	0.63	0.07

Notes:
[1] These data include waterfowl counts from May-98, June-99, July-99, and August-99.
[2] These data include only waterfowl counts from 1999.
[3] Waterfowl counts in May 1998 did not include <200 yard category; only on and off the river counts were recorded.

Based upon these results, no evidence suggests that the hovercraft has affected the distribution of breeding waterfowl or general waterfowl use in the hovercraft operational area on the Kuskokwim River either from the use of the river itself or from the use of areas adjacent to the river. It then follows that the hovercraft is not affecting the number of waterfowl available to subsistence hunting.

Tundra Rivers

In August 1999, habitats of the 11 operational area and seven control area transects across the Johnson and Pikmiktalik Rivers, respectively, were recorded from a helicopter using a video camera. The video tapes were analyzed later to determine the proportions of habitat types along the transects. General habitats were similar between control and hovercraft operational areas (Table 3.8) and did not differ statistically ($p>0.05$). Furthermore, since the amounts of each of the three zones of habitats (river, adjacent, non-river) were specifically measured and used to standardize the waterfowl counts per unit length of habitat zone, any subtle differences in overall habitat will not bias the results. Therefore the results of the control and operational area transects are comparable.

A total of 1,392 waterfowl were counted from the airplane along the 11 transects across the Johnson River (hovercraft operational area) and 1,125 waterfowl were observed along the 7 transects across the Pikmiktalik River (control area) (Table 3.9). A total of 227 waterfowl were observed on the river zone of the Johnson River, and 52 were observed on the river zone of the Pikmiktalik River.

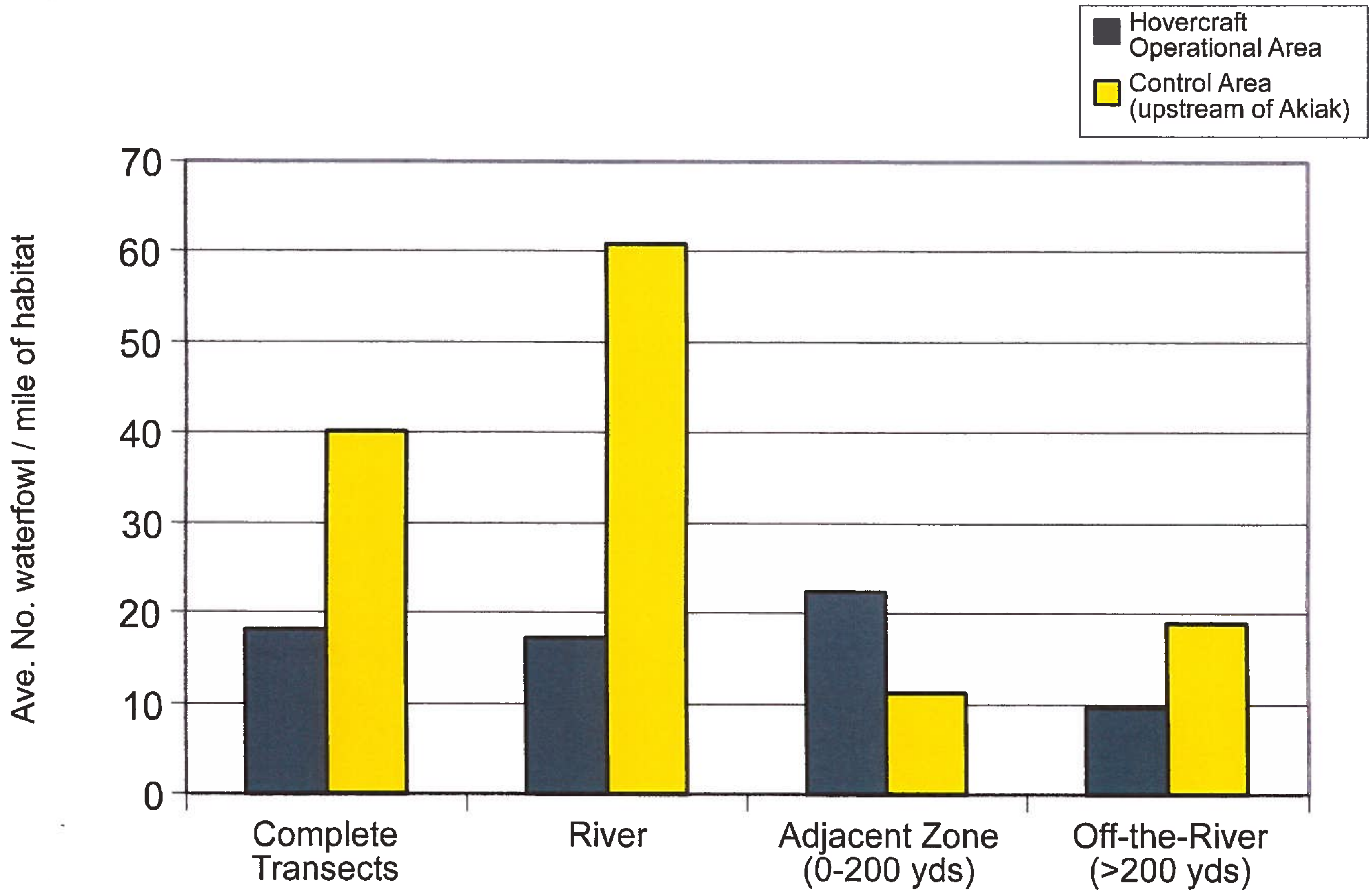
As was the case for the Kuskokwim River surveys, the adjacent zone (<200 yards) was included in the off-river zone in 1998, and thus the 1998 off-river data are presented separately from the 1999 data for the Tundra Rivers. In 1998, 146 waterfowl were observed in the control and 143 waterfowl were observed in the operational area in off-river zones. In 1999, 108 waterfowl were counted along the control and 174 waterfowl were counted along the operational area in the adjacent zones. A total of 819 waterfowl were observed in the control and 849 in the operational area off-river zones.

After standardizing the data based upon the amount of each habitat zone present, the general distribution of numbers of waterfowl observed in the river zone were statistically similar (Table 10) between the control and operational area river, adjacent, and off-river zones ($p>0.05$). These results suggest that waterfowl in similar amounts were using the Johnson and Pikmiktalik River areas. These results indicate that waterfowl use the river, adjacent, and off-rivers zones in similar amounts between both hovercraft operational and control areas (Figure 3.4). Thus it can be concluded that the hovercraft is not affecting the distribution of breeding waterfowl and general waterfowl use of the Johnson River.

Furthermore, no evidence suggests a shift in distribution from waterfowl using the river to those using either adjacent or off-river zones. The river zone on the Johnson River averaged 30.9 waterfowl per mile, higher than the adjacent zone (12.8) and off-river zone (16.0). Similarly, the lack of disparity between the adjacent and off-river zones indicates that waterfowl did not shift from the adjacent zone to the off-river zone, where they might be less accessible to subsistence hunters.

Table 3.8 Percent Habitat Type Comparison for Aerial Waterfowl Survey Transects on the Johnson and Pikmiktalik Rivers

Transect	Marsh	Forest	Unforested upland/tundra	River/lake	Stream/pond slough/mudflat
Johnson River					
J-1	16.0	1.4	54.2	24.3	4.2
J-2	4.7	0.0	82.0	12.5	0.8
J-3	3.9	1.6	80.5	8.6	5.5
J-4	5.5	1.6	63.3	22.7	7.0
J-5	1.4	14.2	47.5	23.4	13.5
J-6	9.6	11.0	55.1	20.6	3.7
J-7	10.9	5.8	60.9	14.5	8.0
J-8	0.0	4.7	58.6	36.7	0.0
J-9	0.0	39.2	24.0	27.2	9.6
P-110	17.1	0.0	63.7	17.6	1.6
P-112	10.9	7.8	57.5	20.2	3.6
Average	**7.3**	**7.9**	**58.8**	**20.8**	**5.2**
Pikmiktalik River					
P-1	3.7	1.5	63.2	17.6	14.0
P-2	5.5	0.0	56.3	18.8	19.5
P-3	27.3	3.8	40.9	9.8	18.2
P-4	22.4	0.0	69.4	6.0	2.2
P-5	10.4	7.2	61.6	20.8	0.0
P-106	5.8	0.0	50.6	24.3	19.3
P-108	4.4	0.0	58.2	26.4	11.0
Average	**12.6**	**1.8**	**56.2**	**17.7**	**11.7**
Mann-Whitney Rank Sum Test					
P-value	0.342	0.085	0.856	0.415	0.103



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Comparison of Waterfowl Abundance Along Aerial Transects Across the Kuskokwim River and Control Area

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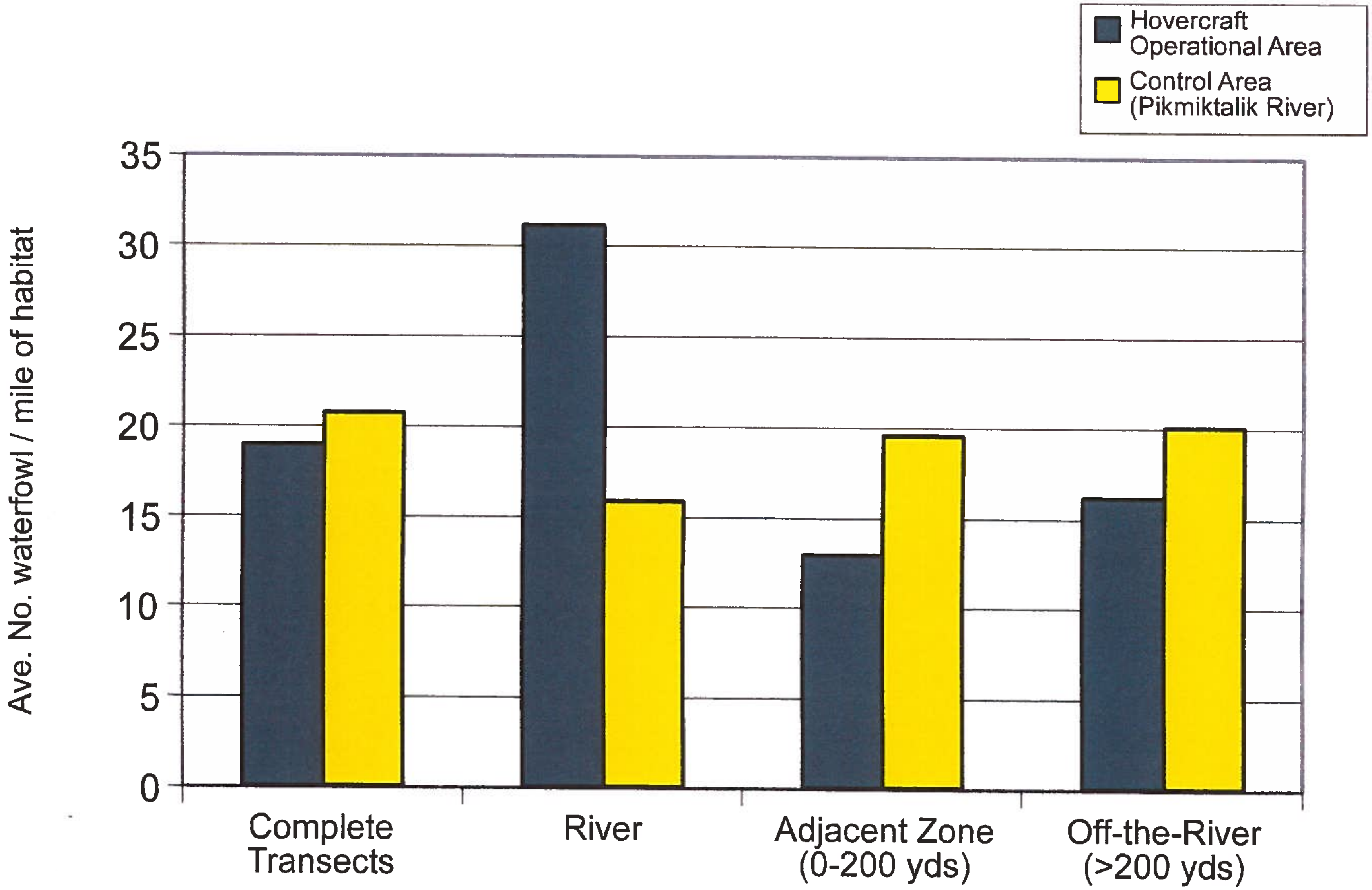
Figure 3.3

Table 3.9 Waterfowl Observations Along Aerial Transects Across the Johnson and Pikmiktalik Rivers

Transect	Transect Length (miles)	Total No. Waterfowl Observed on Transect [1]	No. Waterfowl observed on river[1]	No. Waterfowl observed <200 yards from river[2]	No. Waterfowl observed >200 yards from river [2]	No. Waterfowl observed off-river, May 1998[3]
Control Transects (Pikmiktalik River)						
P-1	2.5	147	5	4	92	46
P-2	2.5	172	2	16	98	56
P-3	2.5	82	25	1	44	12
P-4	2.5	65	1	6	49	9
P-5	2.5	200	5	41	131	23
P-106	4.7	374	7	19	348	--
P-108	3.6	85	7	21	57	--
Totals		**1,125**	**52**	**108**	**819**	**146**
Hovercraft Operational Area (Johnson River)						
J-1	2.5	142	33	38	57	14
J-2	2.5	153	19	13	105	16
J-3	2.5	162	21	6	112	23
J-4	2.5	276	27	25	188	36
J-5	2.5	130	42	23	53	12
J-6	2.5	114	27	8	59	20
J-7	2.5	160	16	17	116	11
J-8	2.5	25	0	9	9	7
J-9	2.5	20	13	3	1	4
P-110	3.7	67	25	28	14	--
P-112	3.6	143	4	4	135	--
Totals		**1,392**	**227**	**174**	**849**	**143**

Notes:
[1] These data include waterfowl counts from May 1998, and June, July, and August 1999.
[2] These data include only waterfowl counts from 1999.
[3] Waterfowl counts in May 1998 did not include <200 yard category; only on and off the river counts were recorded.



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Comparison of Waterfowl Abundance Along Aerial Transects Across the Johnson River and Control Area

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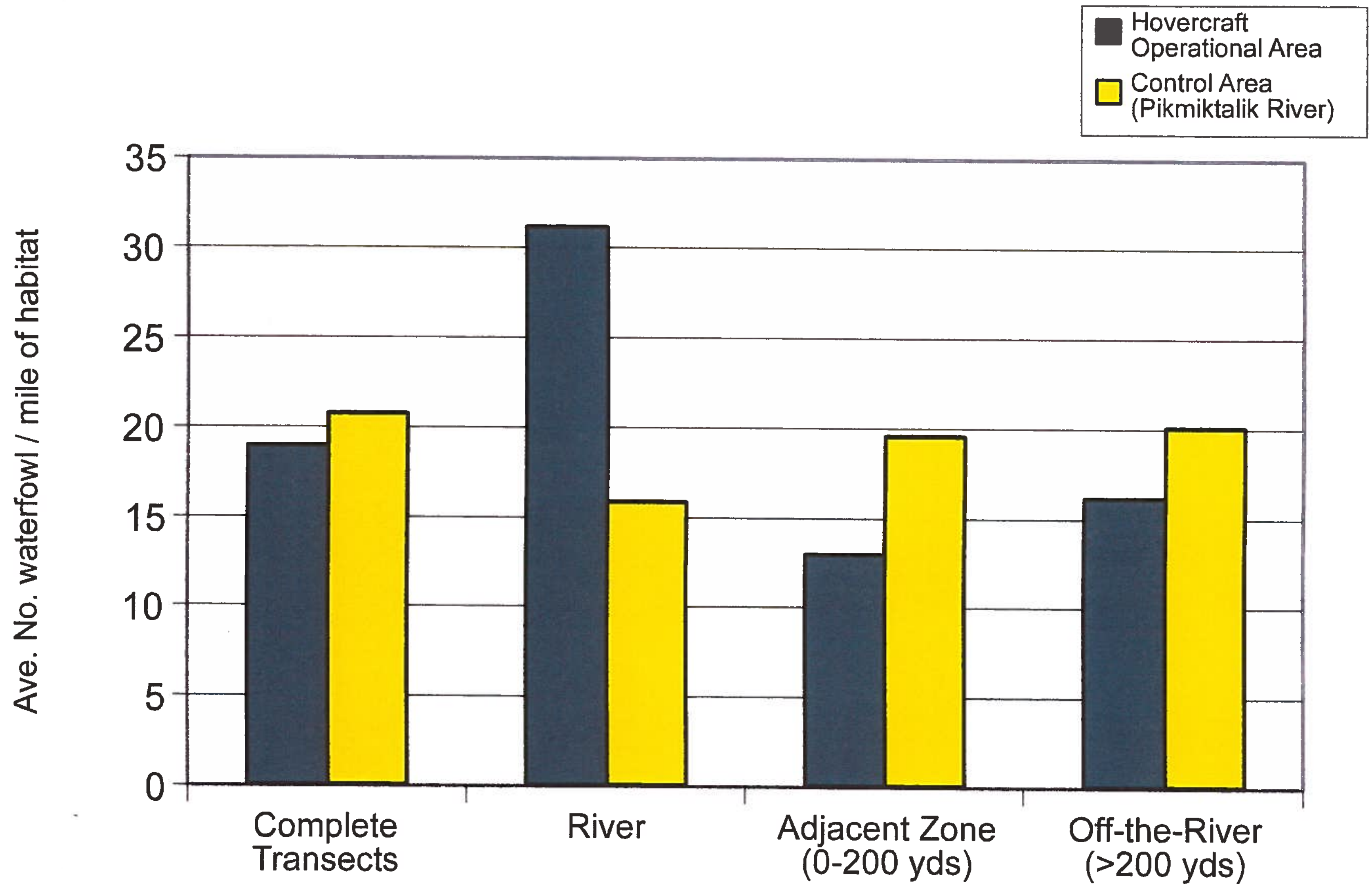
Figure 3.4



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Comparison of Waterfowl Abundance Along Aerial Transects Across the Johnson River and Control Area

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Figure 3.4

When the flushing data are considered with the information from aerial surveys, insight into behavioral responses becomes clearer. If waterfowl were being disturbed to the point of leaving the areas adjacent to the rivers where the hovercraft operates, then the abundance of waterfowl should be greater on rivers not used by the hovercraft, given the similarity of the habitats. The results of the aerial surveys show that the waterfowl flushed by the hovercraft have no more or less propensity to leave the river area. Thus, the hovercraft is not affecting subsistence waterfowl hunting because it is not affecting the distribution of the waterfowl on the rivers where it operates.

The data show no change in relative abundance between areas accessed by the hovercraft and areas not accessed by the hovercraft, refuting the null hypothesis stated above. Based upon the fact that the relative abundance of waterfowl was not significantly different between areas, it follows that although the hovercraft may readily disturb waterfowl, the hovercraft does not affect waterfowl enough for them to stay away from the river any more than motorboats.

The evidence indicates that the hovercraft did not affect the number of waterfowl available for breeding along the transects during 1998. This is based upon observations of similar numbers of waterfowl and flock sizes between areas of the rivers accessed by the hovercraft and not accessed by the hovercraft. Essentially the same numbers of birds were observed in the different areas, and it can be assumed that similar proportions were available for breeding.

Based upon these results, no evidence suggests that the hovercraft has affected the distribution of breeding waterfowl or general waterfowl use in the hovercraft operational area on the Johnson River either from the use of the river itself or from the use of areas adjacent to the river. It then follows that the hovercraft is not affecting the number of waterfowl, nor waterfowl resources such as eggs, available to subsistence hunting.

Table 3.10 Standardized Waterfowl Counts along Aerial Transects across the Johnson and Pikmiktalik Rivers.

Transect	River Habitat (miles)	Habitat <200 yards from River (miles)	Habitat off the River (miles)	No. Waterfowl/ mile of Transect	No. Waterfowl per mile of River Habitat [1]	No. Waterfowl per mile of Habitat <200 yards from River [2]	No. Waterfowl per mile of Habitat >200 yards from River [2]	No. Waterfowl per mile of Habitat off the River (May 1998)[3]
Control Transects (Pikmiktalik River)								
P-1	0.2	0.7	1.6	23	10.6	2.3	21.9	10.9
P-2	0.4	1.0	1.1	26.9	2.3	6.1	34.4	19.7
P-3	0.2	1.7	1.5	12.8	39.7	0.6	11.2	3.1
P-4	0.1	0.2	2.2	10.2	6.9	10.4	8.6	1.6
P-5	0.1	0.2	2.2	31.3	24.4	71.2	23.3	4.1
P-106	0.2	0.2	4.3	31.2	16.8	33	31.7	--
P-108	0.3	0.7	2.7	9.1	9.1	12.3	8.4	--
Average	**0.2**	**0.7**	**2.2**	**20.6**	**15.7**	**19.4**	**19.9**	**7.88**
Hovercraft Operational Area (Johnson River)								
J-1	0.5	1.2	0.9	22.2	27.5	12.8	25.6	6.3
J-2	0.2	0.2	2.1	23.9	47.5	22.6	19.4	2.9
J-3	0.1	0.2	2.2	25.3	84.1	10.4	20.1	4.1
J-4	0.2	0.2	2.1	43.1	60.1	4.04	35	6.7
J-5	0.3	1.0	1.2	20.3	51.4	9.4	16.9	3.8
J-6	0.4	0.2	1.7	17.8	26.1	13.9	12.3	4.2
J-7	0.4	0.2	1.9	25	17.3	29.5	23.7	2.3
J-8	0.8	0.2	1.4	3.9	0.0	15.6	2.4	1.9
J-9	0.7	0.3	1.5	3.1	7.4	3.5	0.3	1.1
P-110	0.6	0.9	2.1	7.1	15.1	12.1	2.6	--
P-112	0.5	0.2	3.0	15.3	3.3	6.9	17.9	--
Average	**0.4**	**0.4**	**1.8**	**18.8**	**30.9**	**12.8**	**16.0**	**3.7**
Mann-Whitney Rank Sum Test								
P-value					0.24	0.50	0.59	0.51

Notes:

[1] These data include waterfowl counts from May 1998, and June, July, and August 1999.

[2] These data include only waterfowl counts from 1999.

[3] Waterfowl counts in May 1998 did not include <200 yard category; only on- and off-the-river counts were recorded.

3.2 Fish Resources

The investigation into possible hovercraft-related detrimental effects on fish resources was implemented through a four-pronged approach. To aid the reader, these results follow the same order as the topics were presented earlier in Section 2.0, *Methods*. The results are presented in the following order:

- Monitoring for adult fish that were stunned or killed by the hovercraft
- Monitoring for juvenile fish that were injured or killed by the hovercraft in shallow areas of the rivers
- Monitoring the potential for the hovercraft to strand fish on low-gradient beaches and hovercraft landing sites
- Monitoring for possible effects on subsistence fishing success

Generally, data for 1998 are presented before 1999, unless the data were combined into one data set. To aid evaluation of the difference between the rivers, the results for the Kuskokwim and Johnson Rivers are typically presented separately.

3.2.1 Potential Adult Fish Mortality

The team evaluated the potential for injury or death of adult fish due to the hovercraft by watching for fish floating on the surface of the water when following directly behind the hovercraft in a motorboat and also when traveling the rivers in motorboats at other times when the hovercraft was not present. The results are presented separately when possible for the Kuskokwim and Johnson rivers because of the different nature of the rivers and the fish that inhabit them. Data collected during 1997-98 and 1999 are combined to provide an overall summary of the results. Sonar fish surveys were conducted during 1999 for the purpose of documenting the presence of fish in the Kuskokwim River and that the potential to observe any effect was indeed present.

Sonar Surveys

At the suggestion of the USFWS, sonar surveys were conducted on the Kuskokwim River during 1999 to document that sufficient numbers of fish were present in the Kuskokwim River during the monitoring campaign. The purpose was to document that, although we were not observing adult fish being harmed by the hovercraft, the potential to make those observations existed. The number of sonar returns for each survey varied from 112 to 555 (Table 3.11). For the purpose of these surveys, sonar returns were considered to be an index of fish present. Although some of the sonar returns might have been debris, they would have been minor given the number of returns recorded and should have been equal between surveys. However, it is possible that on certain days there was more debris in the river following periods of heavy rain. These results show that the number of fish on a survey route varied from day to day. This variation is likely linked to the pulsing nature of salmon migration, as influenced by time of day, tidal stage, and weather conditions. These results also show that there were abundant fish in the river during the monitoring efforts, thus the potential existed for observers to document effects from the hovercraft had they occurred.

Table 3.11 Sonar Surveys Conducted on the Kuskokwim River in 1999

Monitoring Campaign	Date	Route	Sonar Returns
June	16-Jun	2	115
June	18-Jun	2	318
June	19-Jun	1	555
June	21-Jun	1	112
June	22-Jun	1	478
July	7-Jul	1	121
July	8-Jul	1	354
July	8-Jul	2	520
August	20-Aug	1	403
Average No. Returns in June			316
Average No. Returns in July			332
No. Returns in August (only one survey)			403

Dead and Injured Adult Fish Surveys

Seven surveys for floating fish directly behind the hovercraft were conducted on the Kuskokwim River (Table 3.12). In May 1998, one survey, 15 miles long, was conducted. The effort was expanded during 1999 monitoring with an additional 171.8 miles for a two-year total of 186.8 miles of survey behind the hovercraft. During 1999, 52 miles of observations were made less than 10 minutes behind the hovercraft, 24 miles of observations were made 10 to 20 minutes behind the hovercraft, and 35 miles of observations were made 20 to 30 minutes behind the hovercraft (Table 3.12). No dead or injured fish were observed during these 186.8 miles of observations.

Three surveys for floating fish directly behind the hovercraft were conducted on the Johnson River: 54 miles on September 13, 1997; 23 miles on July 9, 1998; and 59 miles on July 13, 1999. During the 1999 survey, 39 miles were less than 10 minutes behind the hovercraft, 14 miles were 10 to 20 minutes behind, and 6 miles were 20 to 30 miles behind (Table 3.12). No dead or injured fish were observed during these 136 miles of observations.

To augment the surveys for dead or injured fish while following the hovercraft, during 1999, observers recorded all fish they saw while working on the hovercraft route along the Johnson and Kuskokwim Rivers. Each day observers recorded how far they traveled that day (excluding when they were following the hovercraft) and any instances of dead or injured fish. A total 3,690 miles were logged during 1999, and only eight fish were observed. The observed fish consisted of seven salmon on the Kuskokwim River and one sheefish on the Johnson River. All but one fish were decomposed and thus could not be collected. No evidence was available that could attribute the cause of death to the hovercraft. The fish were too decomposed to observe gillnet marks, which would indicate that the fish dropped off the nets, the most likely cause of death. The other fish, a chum salmon, was covered in fungus and near death obviously not a result of the hovercraft.

Given that no dead or injured fish were observed behind the hovercraft and based upon the sonar surveys validating the presence of fish, no evidence suggests that the hovercraft is harming the fish in the main channels of all the rivers.

Table 3.12 Fish Mortality Observations

				Distance Observed (miles)					
Month	Date	River	Observer	Unknown Time Behind HC	0-10 min. Behind HC	10-20 min. Behind HC	20-30 min. Behind HC	# Fish Observed	Comments
Sept	09/13/1997	Johnson	RW		54.4			0	
May	05/18/1998	Kuskokwim	SP/PV		15			0	
July	07/09/1998	Johnson	SP/PV		23.1			0	
June	06/15/1999	Kuskokwim	PV	5.1				0	
June	06/16/1999	Both	GS	116.3				0	
June	06/16/1999	Kuskokwim	JB	8				0	
June	06/16/1999	Kuskokwim	SP	14.1				0	
June	06/16/1999	Kuskokwim	SP	0	13.5	2	3.1	0	
June	06/17/1999	Both	GS	118.1				0	
June	06/17/1999	Kuskokwim	RW	58.8				0	
June	06/17/1999	Kuskokwim	JB	108.9				0	
June	06/17/1999	Kuskokwim	SP	21.3				0	
June	06/17/1999	Kuskokwim	SP	0	17.1			0	
June	06/18/1999	Both	GS	123.8				0	
June	06/18/1999	Kuskokwim	SP	33.1				0	
June	06/18/1999	Kuskokwim	SP	0	19.8	18.7		0	
June	06/18/1999	Kuskokwim	RW	51.4				0	
June	06/18/1999	Kuskokwim	JB	26.3				0	
June	06/19/1999	Both	GS	119.4				0	
June	06/19/1999	Both	JB	88.1				0	
June	06/19/1999	Kuskokwim	SP	48.2				0	
June	06/21/1999	Kuskokwim	RW	40.1				0	
June	06/21/1999	Both	GS	118.1				0	
June	06/21/1999	Kuskokwim	JB	33				0	
June	06/21/1999	Kuskokwim	SP	32.5				0	
June	06/21/1999	Kuskokwim	SP	0			0.9	0	
June	06/22/1999	Both	RW	70				0	
June	06/22/1999	Both	JB	90.4				0	
June	06/22/1999	Kuskokwim	SP	55.1				0	
June	06/22/1999	Both	GS	118.8				0	
June	06/23/1999	Kuskokwim	JB	60.6				0	
July	07/07/1999	Both	GS	125				1	chum (not a fresh kill)
July	07/07/1999	Kuskokwim	RW/JD	24.3				0	
July	07/07/1999	Kuskokwim	JB	15				0	
July	07/07/1999	Kuskokwim	SP	14				0	
July	07/08/1999	Kuskokwim	SP	37.6				1	filleted salmon carcass
July	07/08/1999	Kuskokwim	RW/JD	55.7				0	
July	07/08/1999	Kuskokwim	JB	12.4				0	
July	07/08/1999	Both	GS	122.5				0	
July	07/09/1999	Both	GS	120				0	
July	07/09/1999	Kuskokwim	RW/JD	71.9				0	
July	07/09/1999	Kuskokwim	SP/JB	94.1				2	chum (fungus covered, near death); chinook (heavily decomposed)
July	07/09/1999	Kuskokwim	SP/JB	0	1.6	4.8		0	
July	07/10/1999	Both	RW/JD	87.5				1	sheefish (partially decomposed)
July	07/10/1999	Both	JB	81.3				1	sheefish (partially decomposed)
July	07/10/1999	Both	GS	110.6				1	chum (heavily decomposed)
July	07/10/1999	Both	SP	60.4				1	salmon (heavily decomposed)
July	07/10/1999	Kuskokwim	SP	0			30.8	0	
July	07/12/1999	Kuskokwim	SP	65				1	salmon (heavily decomposed)
July	07/12/1999	Both	GS	128.8				0	
July	07/12/1999	Kuskokwim	JB	66.3				0	
July	07/13/1999	Both	JB	55				0	
July	07/13/1999	Both	SP	42.5				0	
July	07/13/1999	Johnson	SP	0	39.3	13.9	6.3	0	
August	08/09/1999	Both	GS	119				0	
August	08/10/1999	Both	GS	119				0	
August	08/11/1999	Both	GS	124				0	
August	08/12/1999	Both	GS	122				0	
August	08/13/1999	Both	GS	122				0	
August	08/13/1999	Kuskokwim	JB	51.3				0	
August	08/13/1999	Kuskokwim	RW/JD	40.8				0	
August	08/14/1999	Both	RW/JD	76.3				0	
August	08/14/1999	Both	JB	30				0	
August	08/16/1999	Kuskokwim	JB/SP	46.9				0	
August	08/17/1999	Both	JB	53.1				0	
August	08/17/1999	Both	SP	53.6				0	
August	08/18/1999	Kuskokwim	SP	61.1				0	
August	08/18/1999	Kuskokwim	JB	65.6				0	
August	08/18/1999	Kuskokwim	RW/JD	61.8				0	
August	08/20/1999	Kuskokwim	JB/RW	54.4				0	
August	08/21/1999	Both	JB	67.5				0	
August	08/21/1999	Both	RW/JD	78.8				0	
Totals	Totals			4297	184	39	41	9	

3.2.2 Potential Juvenile Fish Mortality in Shallow Water Areas

A total of 87 successful beach seinings were conducted during the 1999 monitoring campaigns (Appendix D). Of these, 49 were test seinings, conducted immediately after the hovercraft passed through the observation areas, and 38 were control seinings, conducted before the hovercraft passed through the areas. These efforts resulting in the seining of a total of 8,934 fish (Appendix D), 4,044 of which were caught in test seinings and 4,890 were caught in control seinings. Most of the fish caught in both the test and control seinings were unharmed (Figure 18). A total of 80 (1.9 percent) of the fish caught in the test seinings and 119 (2.4 percent) of the fish caught in the control seinings were dead or injured. Some net-related mortality is unavoidable when such small and fragile fish are caught in beach seines. The data for the Kuskokwim and Johnson Rivers are presented separately because of the differences between their habitats.

Kuskokwim River

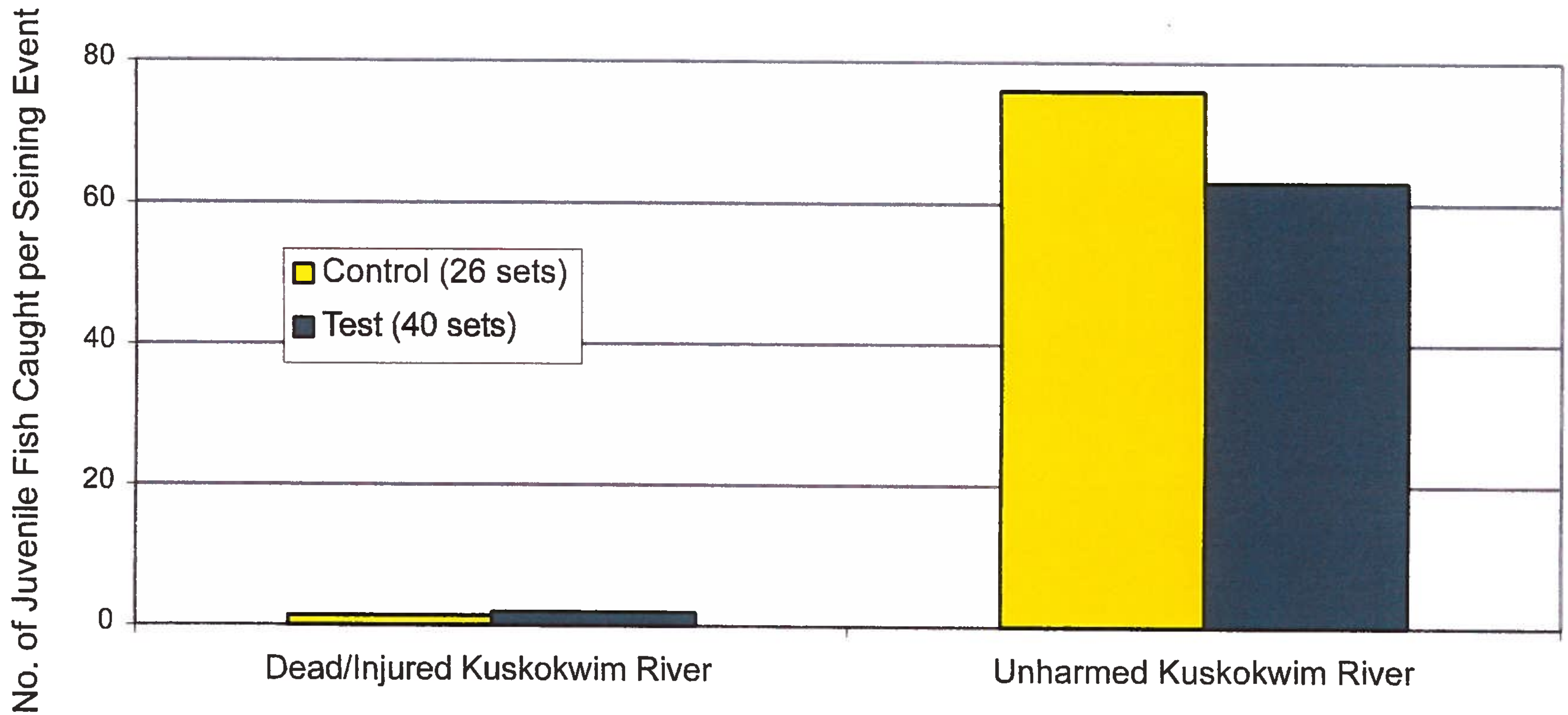
Of the 87 seining efforts, 66 were conducted on the Kuskokwim River. Slightly fewer fish were caught in the test sets than in the control sets, but since the numbers representing the difference were not observed stranded on the beach (Appendix D), it is likely fish moved away from the hovercraft and into deeper water as it passed by. Although the power of the test statistic was only about half of optimum (0.55) (Appendix B), the proportion of dead or injured fish was slightly greater for the test (3.0 percent) than for the control (1.8 percent) ($p<0.05$), suggesting that there is a differential effect between test and control. The average number of dead or injured fish collected on test efforts (1.9 fish) was similar to control efforts (1.4 fish) (Figure 3.5), suggesting that the hovercraft had little absolute effect, if any.

Johnson River

A total of 21 seining efforts was conducted on the Johnson River. As was the case for the Kuskokwim River, fewer fish were captured in the test seines than in the control seines, likely a result of fish moving away from the hovercraft as it passed by. The proportion of dead or injured fish was slightly greater for the control efforts (3.0 percent) than for the test (0.6 percent) ($p<0.05$), suggesting that there is a differential effect between test and control. The average number of dead or injured fish collected on test efforts was very low (0.6 fish) as compared to control efforts (7.0 fish) (Figure 3.6), again suggesting that the hovercraft had little absolute effect, if any.

Kuskokwim and Johnson Rivers Combined

Of the nearly 9,000 fish caught, only a slight fraction were injured and were overwhelmingly from the seine (based upon control results) (Figure 3.7). Since the proportions of the total dead and injured fish to unharmed fish were essentially identical for test (2.0 percent) and control (2.5 percent), it can be concluded from these combined results that the hovercraft does not result in significant mortality to juvenile fish in shallow water areas ($p>0.05$) (Table 3.13). In light of the large number of fish caught in the relatively small 50-foot sweeps of the seine (about 100 fish per effort), the hovercraft would have had to result in large, noticeable kills of fish to represent a significant proportion. Indeed, the fact that there are large numbers of juvenile fish in the shallow areas (based upon the numbers caught in the seines) and at the same time the hovercraft did not result in a differential of mortality, it can be stated with certainty that the hovercraft does not result in significant effects on juvenile fish in the rivers.

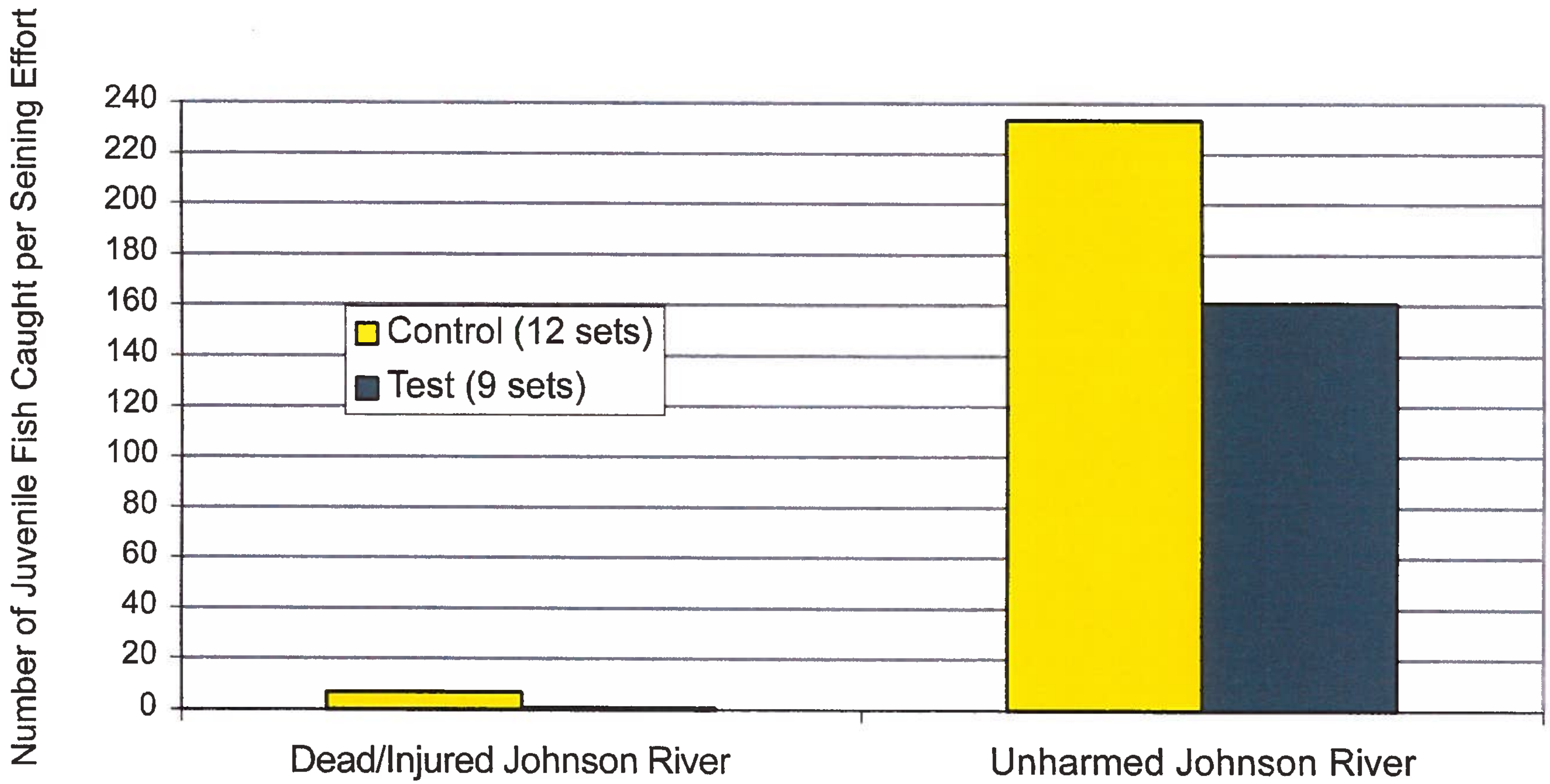


UNITED STATES POSTAL SERVICE

Average Number of Harmed vs Unharmed Fish Collected with Beach Seines on the Kuskokwim River

USPS Transport of Alaska Bypass Mail by Hovercraft Ecological Monitoring Summary Report

Figure 3.5

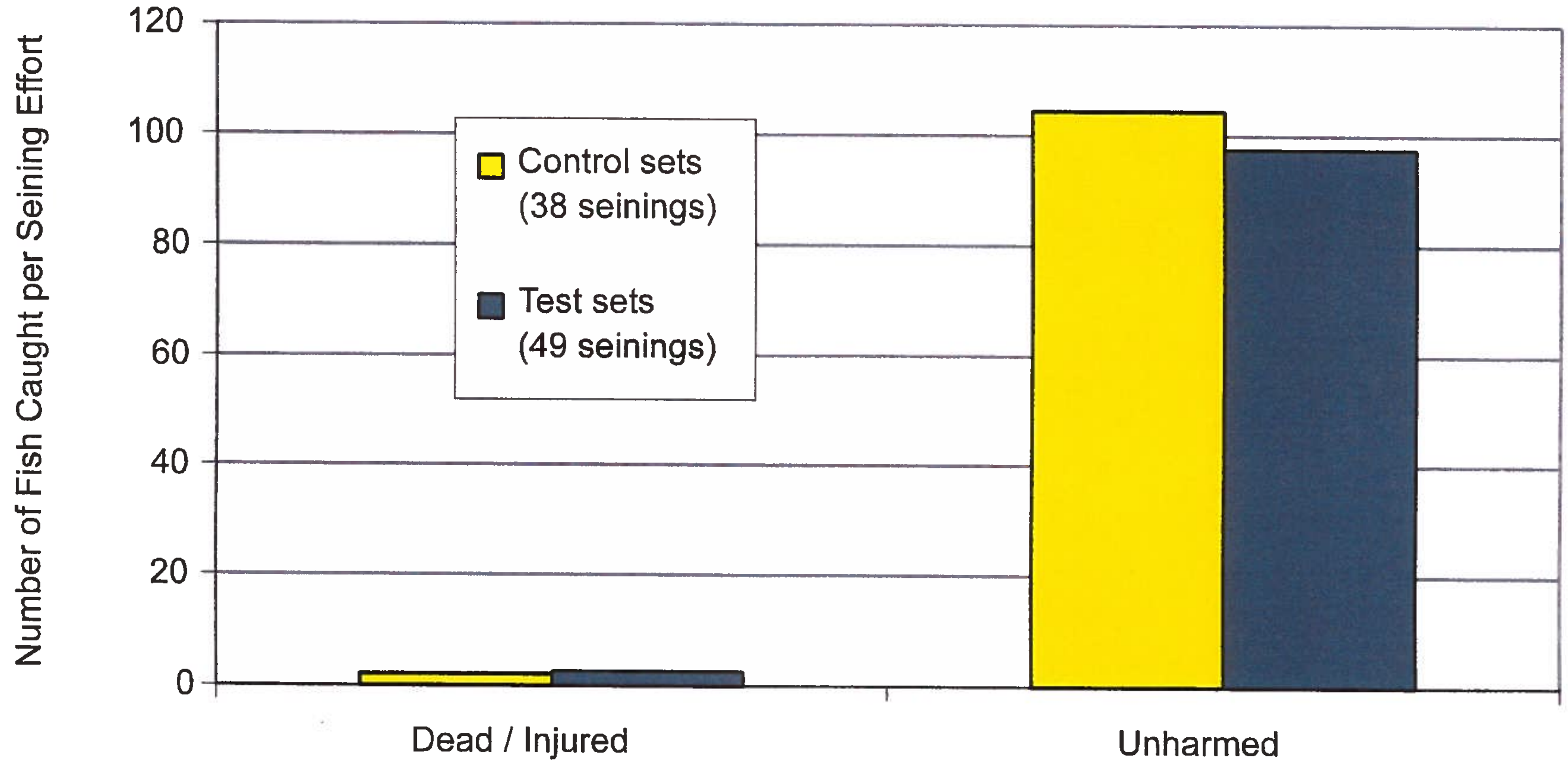


UNITED STATES POSTAL SERVICE

Average Number of Harmed vs Unharmed Fish Collected with Beach Seines on the Johnson River

USPS Transport of Alaska Bypass Mail by Hovercraft Ecological Monitoring Summary Report

Figure 3.6



UNITED STATES POSTAL SERVICE

Number of Harmed vs Unharmed Fish Collected with Beach Seines on Kuskokwim and Johnson Rivers Combined

USPS Transport of Alaska Bypass Mail by Hovercraft Ecological Monitoring Summary Report

Figure 3.7

Table 3.13 Contingency Table Analysis (chi-square) of Beach Seining Results (Both Rivers)

	Dead / Injured	Unharmed
	No. of Fish Observed	No. of Fish Observed
Test Sets	80	3,964
Control Sets	119	4,771

Notes: $p = 0.17$ (X^2 test statistic = 1.90, df = 1, critical value = 3.84)

3.2.3 Stranded Fish on Beaches and Landing Sites

The potential for stranded fish was studied by observing the characteristics of wakes as well as evidence of stranded fish on low-gradient beaches and at landing sites.

Wake Characteristics

A total of 360 wake events were measured during 1997 and 1998 (Appendix C). No significant differences ($p>0.05$) occurred in wave crest height, surge height, or surge distance from wakes produced by hovercraft and other craft (motorboats and tugs/barges) when they were more than 300 feet from shore (Table 3.14). However, statistically significant differences were found when the crafts passed closer to shore. The wave crest height, surge height, and surge distance produced by the hovercraft were all statistically significantly greater ($p<0.05$) than those produced by motorboats when passing less than 100 feet from shore. No observations were available to evaluate the wake characteristics of tugs/barges at this distance because they do not navigate this close to shore.

Alone, these data suggest that the hovercraft has a greater potential to strand fish with its wake than do motorboats when the crafts pass close to shore. However, when the craft are more distant from the shore, the hovercraft potential is similar to that of tugs and motorboats. Finally, the fact that the hovercraft produces a slightly larger wake than motorboats when near shore, and suggesting it could have a greater potential to strand fish, does not mean that it does actually strand more fish. A great number of additional variables need to be considered before drawing a conclusion that a one-foot wave actually strands fish. Based on these results, new investigations were implemented in 1999 that looked more closely at the potential for stranding.

Table 3.14 Wake Characteristics from Hovercraft and other Watercraft (1997 and 1998 data).

Watercraft Type	Average Speed (knots)	Average distance from shore (feet)	Average wave crest Height (in)	Average wave surge height (in)	Average wave surge distance (feet)
Distance from shore (<100 ft)					
Motorboat	18.2	51.5	3.79	1.25	1.96
Hovercraft	26.2	46.6	15.6	3.70	6.61
t-test (P-value)			<0.001	<0.001	0.005
Distance from shore (300-500 ft)					
Motorboat	19.5	404.9	2.81	1.00	2.03
Hovercraft	21.7	433.3	4.00	1.25	2.00
Tug/Barge	10.0	400.0	3.00	1.75	2.75
ANOVA (P-value)			0.09	0.10	0.55

Stranding on Beaches

During 1998 monitoring, efforts for observing stranded fish along beaches were conducted mostly in May. No stranded fish were observed as a result of hovercraft or other types of wakes on beaches in May 1998 (Table 3.15), despite checking more than 13,000 yards of beach. These results indicate that the wave does not result in stranded fish.

A total of five stranded fish was found on beaches during August 1998, but they were not attributable to the hovercraft because it was not operating on that day or on the prior two days. The condition of the fish suggested they were less than one day old.

Observations for stranded fish were conducted in 1999 at beach seining sites and when the hovercraft made unplanned stops on some beaches. As opposed to 1998, the 1999 observations were of the hovercraft when it was running within 50 feet of the shore in shallow water. A total of 7,405 yards of beach was checked during these observations and only 59 stranded fish were observed that could be attributable to the hovercraft (Appendix D). Most of the stranded fish were juvenile whitefish, but there were also a few chum salmon and longnose suckers. The rate of stranding would result in only 13 juvenile fish being stranded in an entire mile of beach. Based on the number of juvenile fish present from the seining information, a conservative estimate would be approximately 11,000 juvenile fish close to the shore in a mile of beach. If the hovercraft passed close to the shore along that mile, 13 fish would be expected to be stranded. This number is a miniscule fraction (0.1 percent) of the number of fish present. In addition, these few stranded fish might serve as food for gulls and terns in place of fish in the water, saving fish still in the water.

Two conclusions can be drawn for the two years of data. First, the hovercraft wave does not strand fish, based upon observing more than 13,000 yards of beach. Second, when operating close to shore in shallow water, the hovercraft strands an insignificant number of juvenile fish on beaches that does not result in an impact to the fish populations in the rivers.

Stranding at Hovercraft Landing Sites

Hovercraft landing sites with relatively flat beaches were checked for stranded fish immediately after the hovercraft came ashore during the July and August 1998 campaigns. Landing sites checked included the villages of Kwethluk, Akiak, Akiachak, Napakiak, and Napaskiak. All village landing sites were checked during each monitoring campaign in 1999. The 1998 results are presented first, followed by the 1999 results.

Two unidentified small fish were observed stranded at the landing in Kwethluk on July 8, 1998, after the Hovercraft came ashore (Table 3.16). It could not be determined how long the fish had been at the landing from their condition, and since the beach was not checked before hovercraft's arrival, it cannot be known for certain if the hovercraft was the cause. No other stranded fish were observed at landing sites in 1998.

A total of 63 hovercraft landings was checked for stranded fish in 1999 (Table 16), with 67 stranded fish observed. These occurrences were observed at only 13 of the landings, indicating that most landings wwere not associated with stranded fish. All landings where fish were observed were on the Kuskokwim River. No stranded fish were observed at the Kasigluk and Nunapitchuk landing sites. These numbers are minor, when considering that there are

Table 3.15 Fish Stranding Observations (1997 and 1998)

Date	Station	Hovercraft	Species	Number stranded
SEPTEMBER 1997				
9/15/97	KU-1	Yes	N/A	0
9/15/97	KU-3	No	N/A	0
9/15/97	KU-3	No	N/A	0
9/15/97	KU-3	No	N/A	0
9/15/97	KU-3	No	N/A	0
9/15/97	KU-3	Yes	N/A	0
9/15/97	KU-5	No	N/A	0
9/15/97	KU-5	No	N/A	0
9/15/97	KU-5	No	N/A	0
9/15/97	KU-5	No	N/A	0
9/15/97	KU-5	No	N/A	0
9/15/97	KU-5	No	N/A	0
9/15/97	KU-5	Yes	N/A	0
9/15/97	KU-7	No	N/A	0
9/15/97	KU-7	Yes	N/A	0
9/15/97	KU-7	No	N/A	0
9/15/97	KU-7	No	N/A	0
9/15/97	KU-2	Yes	N/A	0
9/15/97	KU-4	Yes	N/A	0
9/15/97	KU-4	No	N/A	0
9/15/97	KU-4	No	N/A	0
9/15/97	KU-4	No	N/A	0
9/15/97	KU-4	No	N/A	0
9/15/97	KU-6	No	N/A	0
9/15/97	KU-6	No	N/A	0
9/15/97	KU-6	No	N/A	0
9/15/97	KU-6	No	N/A	0
9/15/97	KU-6	No	N/A	0
9/15/97	KU-6	Yes	N/A	0
9/15/97	KU-8	Yes	N/A	0
9/15/97	KU-8	No	N/A	0
9/15/97	KU-8	No	N/A	0
9/15/97	KU-8	No	N/A	0
9/16/97	JO-1	Yes	N/A	0
9/17/97	KU-9	Yes	N/A	0
9/17/97	KU-11	Yes	N/A	0
9/17/97	KU-13	No	N/A	0
9/17/97	KU-13	Yes	N/A	0
9/17/97	KU-14	No	N/A	0
9/17/97	KU-14	No	N/A	0
9/17/97	KU-14	No	N/A	0
9/17/97	KU-14	No	N/A	0
9/17/97	KU-14	No	N/A	0
9/17/97	KU-6	Yes	N/A	0[1]
9/17/97	KU-10	Yes	N/A	0
9/17/97	KU-12	No	N/A	0
9/17/97	KU-12	Yes	N/A	0
9/17/97	KU-12	No	N/A	0
9/17/97	KU-12	No	N/A	0
9/17/97	KU-12	No	N/A	0
9/17/97	KU-12	No	N/A	0
9/18/97	JO-2	Yes	N/A	0

Table 3.15 Fish Stranding Observations (1997 and 1998) (cont.)

Date	Station	Hovercraft	Species	Number stranded
MAY 1998				
5/18/98	K-3	No	N/A	0
5/18/98	KS-1	No	N/A	0
5/18/98	KS-1	Yes	N/A	0
5/18/98	KS-1	No	N/A	0
5/18/98	KS-1	Yes	N/A	0
5/18/98	KS-1	No	N/A	0
5/18/98	KS-1	Yes	N/A	0
5/19/98	JS-1	Yes	N/A	0
5/22/98	KS-1	No	N/A	0
5/22/98	KS-2	No	N/A	0
5/22/98	KS-2	No	N/A	0
JULY 1998				
7/8/98	KS-2	No	N/A	0
7/8/98	KS-2	No	N/A	0
7/8/98	KS-2	No	N/A	0
7/8/98	KS-2	No	N/A	0
7/8/98	KS-2	No	N/A	0
7/9/98	KS-2	No	N/A	0
7/9/98	KS-2	No	N/A	0
7/9/98	KS-3	No	N/A	0
7/9/98	KS-3	No	N/A	0
7/9/98	KS-3	No	N/A	0
7/9/98	KS-1	No	N/A	0
7/9/98	KS-1	No	N/A	0
7/10/98	KS-3	No	N/A	0
7/10/98	KS-3	No	N/A	0
7/10/98	KS-3	No	N/A	0
7/10/98	KS-3	No	N/A	0
7/10/98	KS-3	No	N/A	0
7/10/98	KS-3	No	N/A	0
7/10/98	KS-3	No	N/A	0
7/10/98	KS-3	No	N/A	0
7/10/98	KS-3	No	N/A	0
7/10/98	KS-3	No	N/A	0
AUGUST 1998				
8/24/98	Bethel Point	No	N/A	0[2]
8/24/98	Bethel 1	No	N/A	0
8/24/98	Bethel 2	No	N/A	0
8/24/98	Bethel 3	No	N/A	0[3]
8/24/98	Bethel 4	No	N/A	0
8/24/98	Bethel 5	No	N/A	0
8/24/98	Kwethluk 6	No	N/A	0

1 A whitefish was observed on the beach at the time of arrival. Observation cannot be positively linked to hovercraft operations.

2 Four longnose suckers were observed on the beach at the time of arrival. Observation cannot be positively linked to hovercraft operations.

3 One longnose sucker was observed at the beach at the time of arrival. Observation cannot be positively linked to hovercraft operations.

Table 3.16. Stranded Fish Observations at Hovercraft Landing Sites in 1998 and 1999

Month	Date	Station	Number Observed	Species	Fish Observed Dead	Injured	Unharmed	Distance From Water
July	07/07/1998	Napakiak	0	-	-	-	-	-
July	07/08/1998	Kwethluk	2	unknown	2	-	-	not recorded
July	07/08/1998	Akiak	0	-	-	-	-	-
July	07/08/1998	Akiachak	0	-	-	-	-	-
July	07/08/1998	Napaskiak	0	-	-	-	-	-
July	07/09/1998	Napakiak	0	-	-	-	-	-
August	08/19/1998	Kwethluk	0	-	-	-	-	-
August	08/19/1998	Akiak	0	-	-	-	-	-
August	08/19/1998	Akiachak	0	-	-	-	-	-
August	08/19/1998	Napaskiak	0	-	-	-	-	-
August	08/20/1998	Napakiak	0	-	-	-	-	-
August	08/21/1998	Kwethluk	0	-	-	-	-	-
August	08/21/1998	Akiak	0	-	-	-	-	-
August	08/21/1998	Akiachak	0	-	-	-	-	-
August	08/21/1998	Napaskiak	0	-	-	-	-	-
August	08/25/1998	Napakiak	0	-	-	-	-	-
June	06/15/1999	Napakiak	0	-	-	-	-	-
June	06/15/1999	Nunapitchuk	0	-	-	-	-	-
June	06/15/1999	Kasigluk	0	-	-	-	-	-
June	06/16/1999	Kwethluk	0	-	-	-	-	-
June	06/16/1999	Akiak	0	-	-	-	-	-
June	06/16/1999	Akiachak	0	-	-	-	-	-
June	06/17/1999	Napakiak	8	chum salmon	-	8	-	20-30 ft
June	06/18/1999	Kwethluk	0	-	-	-	-	-
June	06/18/1999	Akiak	0	-	-	-	-	-
June	06/18/1999	Akiachak	13	chum salmon	13	-	-	5-25 ft
June	06/19/1999	Napakiak	8	chum salmon (7), pike (1)	-	8	-	5-15 ft
June	06/19/1999	Nunapitchuk	0	-	-	-	-	-
June	06/19/1999	Kasigluk	0	-	-	-	-	-
June	06/21/1999	Napaskiak	0	-	-	-	-	-
June	06/21/1999	Napakiak	0	-	-	-	-	-
July	07/09/1999	Kwethluk	25	whitefish	25	-	-	5ft
July	07/09/1999	Akiak	0	-	-	-	-	-
July	07/09/1999	Akiachak	17	whitefish	17	-	-	5-50ft
July	07/09/1999	Napaskiak	0	-	-	-	-	-
July	07/09/1999	Kwethluk	0	-	-	-	-	-
July	07/09/1999	Akiachak	2	whitefish	2	-	-	not recorded
July	07/10/1999	Napaskiak	1	whitefish	1	-	-	not recorded
July	07/10/1999	Nunapitchuk	0	-	-	-	-	-
July	07/10/1999	Kasigluk	0	-	-	-	-	-
July	07/12/1999	Napaskiak	0	-	-	-	-	-
July	07/12/1999	Kwethluk	0	-	-	-	-	-
July	07/12/1999	Akiak	0	-	-	-	-	-
July	07/12/1999	Akiachak	0	-	-	-	-	-
July	07/13/1999	Napakiak	4	whitefish (3); sucker (1)	4	-	-	2-25ft
July	07/13/1999	Nunapitchuk	0	-	-	-	-	-
July	07/13/1999	Kasigluk	0	-	-	-	-	-
July	07/14/1999	Kwethluk	1	whitefish	1	-	-	10ft
July	07/14/1999	Akiak	0	-	-	-	-	-
July	07/14/1999	Akiachak	1	sheefish	1	-	-	30ft
July	07/14/1999	Napaskiak	0	-	-	-	-	-
August	08/13/1999	Kwethluk	0	-	-	-	-	-
August	08/13/1999	Akiak	0	-	-	-	-	-
August	08/13/1999	Akiachak	0	-	-	-	-	-
August	08/13/1999	Napaskiak	0	-	-	-	-	-
August	08/14/1999	Napakiak	2	whitefish	-	2	-	20ft
August	08/14/1999	Kasigluk	0	-	-	-	-	-
August	08/16/1999	Akiachak	1	whitefish	1	-	-	30ft
August	08/16/1999	Kwethluk	0	-	-	-	-	-
August	08/16/1999	Napaskiak	0	-	-	-	-	-
August	08/16/1999	Kwethluk	0	-	-	-	-	-
August	08/16/1999	Akiachak	0	-	-	-	-	-
August	08/17/1999	Kasigluk	0	-	-	-	-	-
August	08/17/1999	Napakiak	0	-	-	-	-	-
August	08/18/1999	Kwethluk	0	-	-	-	-	-
August	08/18/1999	Akiak	0	-	-	-	-	-
August	08/18/1999	Akiachak	0	-	-	-	-	-
August	08/18/1999	Napaskiak	0	-	-	-	-	-
August	08/20/1999	Kwethluk	0	-	-	-	-	-
August	08/20/1999	Akiak	0	-	-	-	-	-
August	08/20/1999	Akiachak	0	-	-	-	-	-
August	08/20/1999	Napaskiak	0	-	-	-	-	-
August	08/21/1999	Napakiak	0	-	-	-	-	-
Totals			85		67	18	0	

thousands of fish in shallow areas in front of the landings (based on seining study results), and considering the minor amount of area used compared to the great expanse of habitat present.

These results indicate that hovercraft landing operations result in little mortality to juvenile fish in the Kuskokwim River and no mortality to juvenile fish in the Johnson River. Relative to the number of fry present in the Kuskokwim River, which could be several hundred million, the effect of the few fry stranded at the landing sites is negligible and would not have an impact on the overall population.

3.2.4 Subsistence Fishing

Gillnet Catch

To assess the possible effect of the hovercraft on subsistence gillnet fishing success, a total of 110 paired net sets were conducted with 39 conducted in 1998 and 71 conducted in 1999 (Appendix F). Performing very short sets (30 minutes or less) allowed the monitoring team to focus testing on the hovercraft passing by (treatment variable) and thus minimize the potential influence of other environmental variables, such as pulsing (large schools in a short time period), which would tend to manifest over longer time periods.

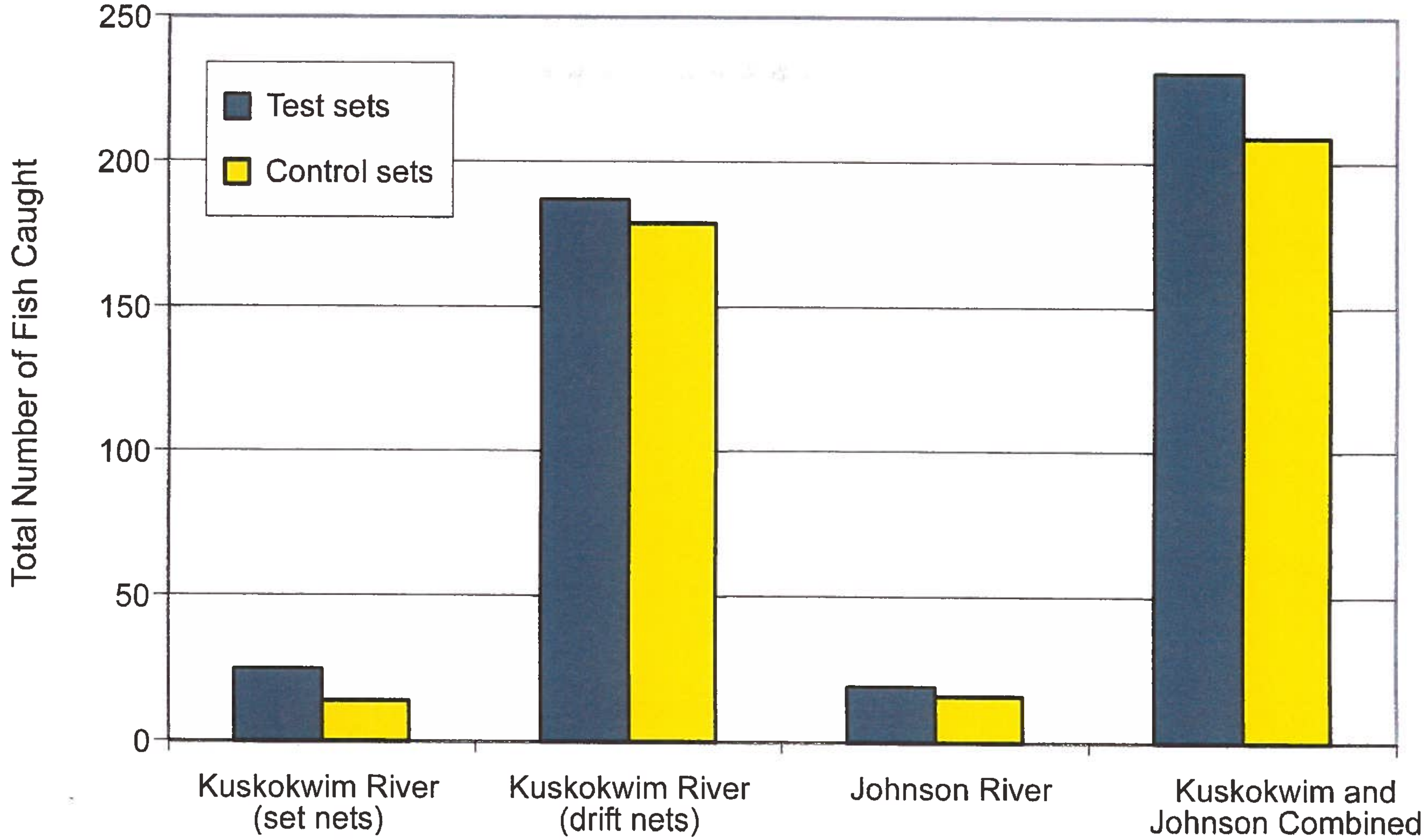
The use of drift nets rather than set nets provided more data (greater catches) suitable for statistical testing. Therefore, the use of drift nets was emphasized in 1999. This fishing method was very successful, particularly on the Kuskokwim River, where 49 paired sets resulted in 366 fish caught, 187 in the test sets and 179 in the control sets (Figure 3.8); only six paired sets resulted in no fish caught. This method was also used on the Johnson River midway through the 1999 monitoring, in conjunction with set nets, to increase the amount of data available for statistical analysis.

For this study, higher catches in test sets would indicate that fish are being driven into the nets, thus improving fishing success. Higher catches in control sets would indicate that the opposite was occurring. In both 1998 and 1999, the difference between test and control catch rates was not statistically significant ($p>0.05$ for all comparisons). Thus even with a large statistical sample size (110 paired tests) no adverse effect of the hovercraft could be discerned.

Winter Blackfish Fishing

The fishing method used to catch blackfish on the Johnson River in mid-winter involves cutting a hole in the ice and waiting for the fish to swim into the opening where they concentrate in large numbers (Joe Nicholas, pers. comm.). The fish are apparently drawn to the holes by the oxygen available at the surface of the water within these holes, because depleted oxygen conditions exist under the ice during winter. Fishermen were often observed clearing the hole of ice and covering the hole with cardboard or plywood, followed by a layer of snow. This insulating layer, in conjunction with the movement of the blackfish, tends to keep the hole free of ice and allows the fish to gulp air (Gerry Demientieff, pers. comm.; Steve Kinegak, pers. comm.).

The design of the traps observed on the Johnson River were of a cylinder constructed of small-mesh wire cloth, with one end open, into which a funnel constructed of strips of wood was placed and secured with twine. The traps were about 3 to 4 ft long and about 18 inches in diameter. The traps observed during field observations were fished with the traps oriented vertically in the hole, with the funnel-end of the traps located approximately 10-12 inches below



Results of Gillnet Fishing Experiments

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Figure 3.8

the surface of the water. The traps were secured in place with a line; one end tied to the trap and the other end to a board or stick above the surface of the ice (Figure 3.9).

Seventeen fishing holes were observed along the hovercraft route on the Johnson River, with the majority located about one mile below the village of Kasigluk (Figure 3.10). The majority of the fishing holes appeared to be active sites, with signs of recent checking apparent, including freshly shoveled snow and dead blackfish on the snow around the holes. The only location where holes did not appear to have been checked recently was the group of holes farthest from the village downstream, near Lake Nunavarq, and the hole next to Nunapitchuk. The five fishing holes near Lake Nunavarq were located along a small slough off the main river, with only one hole near the mouth of the slough, close to the main river. The holes showed no signs of recent checking and one gave off a carrion-like order, suggesting that dead fish might have been abundant in the hole. The reason that no fishing holes were found along the branch of the Johnson River immediately below Nunapitchuk seems to be related to low water conditions during the fall. Fishermen usually put traps in at the mouth of the several small sloughs just below the village, but this year the low water conditions caused the blackfish to stay in the lakes and not come out to the river as they normally do, so they did not fish in this location this year (John Berlin, pers. comm.).

Fishing Success

Fishing success was reported to have improved only within the last two weeks prior to the field observation period (Gerry Demientieff, pers. comm., Levi Brink, pers. comm.). Several fishermen reported that they were catching many more blackfish this year than during the previous two winter seasons and had pulled their traps because they had plenty of blackfish stored away (Esi Twitchell, pers. comm.; Levi Brink, pers. comm.; and others).

Fishing success in the hole used for the underwater observations seemed to decline over the course of the field observations (Table 3.17). The apparent decline in success also corresponded to a decline in dissolved oxygen concentrations in the water within the hole. The decline in dissolved oxygen could be from a natural downstream expansion of anoxic conditions as the winter season progresses.

Table 3.17 Fishing Success in the Fishing Hole Used for the Underwater Observations

Date	Catch Amount	Approximate Time Fished
January 24, 2000	Full Trap	72 Hours
January 25, 2000	½ Trap	24 Hours
January 26, 2000	¼ Trap	24 Hours
January 27, 2000	Not Checked	--
January 28, 2000	1/5 Trap	48 Hours

Blackfish Behavioral Observations

Underwater observations of blackfish behavior in response to the hovercraft traveling past the fishing hole were recorded for a total of twenty pass-bys (Table 3.18). The results of the underwater observations revealed that during the majority of the pass-bys, there was very little or no reaction from the blackfish. During a few of the pass-bys there was a temporary reaction in which some of the blackfish swam down away from the surface, while others showed no

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Typical Trap Used to Fish for Blackfish on the Johnson River

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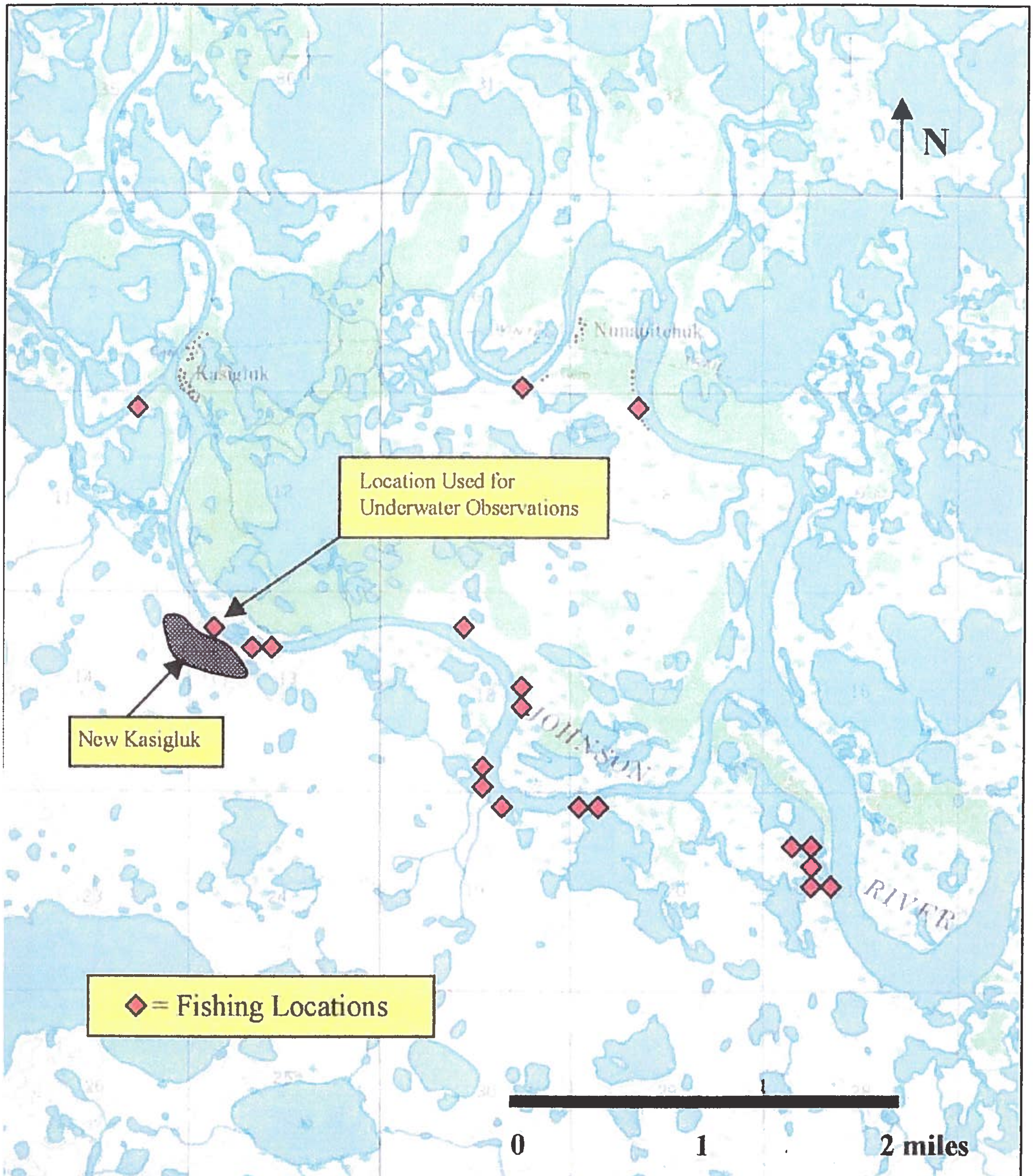
Figure 3.9



Blackfish Fishing Locations Observed Jan.25 to 29, 2000.

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Figure 3.10

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Table 3.18 Underwater Observations of Blackfish Behavior in relation to the Hovercraft, conducted in the Johnson River at Kasigluk, on January 25 through January 28, 2000

Date / Tape No.	Time	Tape Counter	Approximate Distance Hovercraft passed by Hole (feet)	Observations
1/25/00 Tape #1	12:10pm to 1:43pm	--	NA	General behavioral observations prior to the hovercraft's arrival at Kasigluk
1/25/00 Tape #2	1:43pm	0:0	NA	Started Tape
1/25/00 Tape #2	1:59:24pm	16:41	90	Fish and water moved up and down approximately (max.4 inches) for about 10sec; then 3 fish swam into trap. Fish agitated but did not scatter; numerous fish in view immediately following pass.
1/25/00 Tape #2	2:10pm	31:38	NA	Fisherman cleared ice from hole; fish swam down away from surface.
1/25/00 Tape #2	2:21pm	38:40	84	Slower pass; water rose about 0.5 to 1.0 inches, no apparent reaction of fish.
1/25/00 Tape #2	2:22pm	39:41	78	Water rose about 0.5 to 1.0 inches, no apparent reaction of fish.
1/25/00 Tape #2	2:24pm	41:40	100	Very slight movement of water, no reaction of fish.
1/25/00 Tape #2	2:26pm	43:30	100	Water rose in hole about 2 inches, no apparent reaction of fish.
1/25/00 Tape #2	2:28pm	46:30	118	No change in water level, no reaction of fish.
1/25/00 Tape #2	2:30pm	47:34	84	Water rose 3-4 inches, fish moved up and down with water, fish appear slightly agitated, but stay in hole.
1/25/00 Tape #2	2:33pm	50:30	105	Water rose about 1 inch, then dropped about 2 inches below initial elevation, trap moved by surge of water, fish moved up and down by water surge, fish appear agitated but do not scatter, a few swim into trap immediately after pass.
1/25/00 Tape #2	2:34pm	51:43	100	Water rose about 4 inches, fished moved up and down with the water movement, but did not display any reaction.
1/25/00 Tape #2	2:37pm	54:47	105	Water rose dropped 1-2 inches, then rose 1 inch above initial level, trap moved, but fish did not react.
1/25/00 Tape #2	2:39pm	56:44	100	Water rose about 4 inches, trap moved and about half the fish displayed a reaction by swimming downward, but remaining ones did not react.
1/25/00 Tape #2	2:43pm	1:00:32	105	Water rose 2 inches then dropped 1 inch below initial level, trap moved and a few fish reacted by swimming downward, majority did not react.
1/25/00 Tape #2	3:12pm	1:30	NA	Stopped Recording

Table 3.18 (cont.) **Underwater Observations of Blackfish Behavior in relation to the Hovercraft, conducted in the Johnson River at Kasigluk, on January 25 through January 28, 2000**

Date / Tape No.	Time	Tape Counter	Approximate Distance Hovercraft passed by Hole (feet)	Observations
1/26/00 Tape #3	11:36am	0:0 to 8:10	NA	General observations of blackfish and trap in fishing observation hole. Hovercraft did not travel on Johnson River on this date.
1/26/00 Tape #3	11:48am	8:10 to 9:36	NA	General observations in sound observation hole. No blackfish observed in water column, 3 blackfish in hole (2 dead, 1 alive).
1/28/00 Tape #3	12:44pm	9:36	NA	General behavioral observations prior to the hovercraft's arrival at Kasigluk
1/28/00 Tape #3	1:14pm	29:33	NA	Snowmobile drove up within 10ft of hole and sat there idling for approx. 5 min., no reaction by fish.
1/28/00 Tape #3	2:14:30pm	1:30	NA	Stopped recording
1/28/00 Tape #4	2:15pm	0:0	NA	Started recording
1/28/00 Tape #4	2:33pm	17:05	90	Majority of fish displayed a response and swam down, with 9 fish swimming into the trap, large amount of gas bubbles observed rising during hovercraft pass, fewer fish in view immediately after hovercraft pass, however fish soon returned to field of view (approx. 3 to 5 minutes).
1/28/00 Tape #4	3:16pm	1:00:30	90	Approximately 20-30 fish observed displaying rapid downward swimming during pass, with many swimming into the trap, gas bubbles observed again, and fish soon returned (approx. 2 minutes).
1/28/00 Tape #4	3:18pm	1:03	50	No obvious sign of pass on tape: no reaction by fish or movement of water or trap.
1/28/00 Tape #4	3:20pm	1:05:40	70	Water and trap moved during pass, but fish did not display any reaction. Fewer fish in view than during initial pass.
1/28/00 Tape #4	3:23pm	1:08:05	70	Water and trap moved, increased amount of gas bubbles, rapid downward swimming of many fish, some into trap, but fish did not leave area, they began swimming back into view soon after pass.
1/28/00 Tape #4	3:25pm	1:10:10	70	Water and trap moved slightly back and forth horizontally, but fish displayed no obvious reaction to pass, there were fewer fish in view than during previous pass.
1/28/00 Tape #4	3:27:30pm	1:12:33	80	Water and trap moved horizontally about 1-2 inches, increased amount of gas bubbles, downward swimming of many fish, several into trap, but fish did not scatter and leave area, but began swimming back into view soon after pass.
1/28/00 Tape #4	3:30pm	1:15:10	100	No obvious sign of pass on tape: no reaction by fish or movement of water or trap.
1/28/00 Tape #4	3:47pm	1:32:07	NA	Stopped recording

apparent reaction. However, the observations also revealed that this reaction was of a short duration and that the fish soon returned to the hole, usually within a few minutes. In addition, when the blackfish swam downward they were often observed swimming directly into the fishing trap.

The blackfish reacted little and inconsistently to hovercraft pass-bys very close to the hole as well as those further from the hole, suggesting that distance of pass-by from the hole had minimal affect on the response (Table 3.18). Similarly, no consistent, notable reactions were observed in relation to varying cargo loads and RPMs of the lift motors. In summary, the operation of the hovercraft appears to have little effect on blackfish behavior and blackfish fishing success.

Underwater Sound Measurements

The results of the underwater sound measurement are summarized here and reported in detail in the *Draft Hovercraft Underwater Noise Measurements in Alaska* (USPS, 2000). Figures 3.11 and 3.12 present comparisons of hovercraft and snowmobile underwater maximum sound pressures and maximum exposure levels. The maximum sound pressure level is a measure of the maximum instantaneous sound level recorded, whereas the maximum exposure level represents the total sound energy associated with a given event.

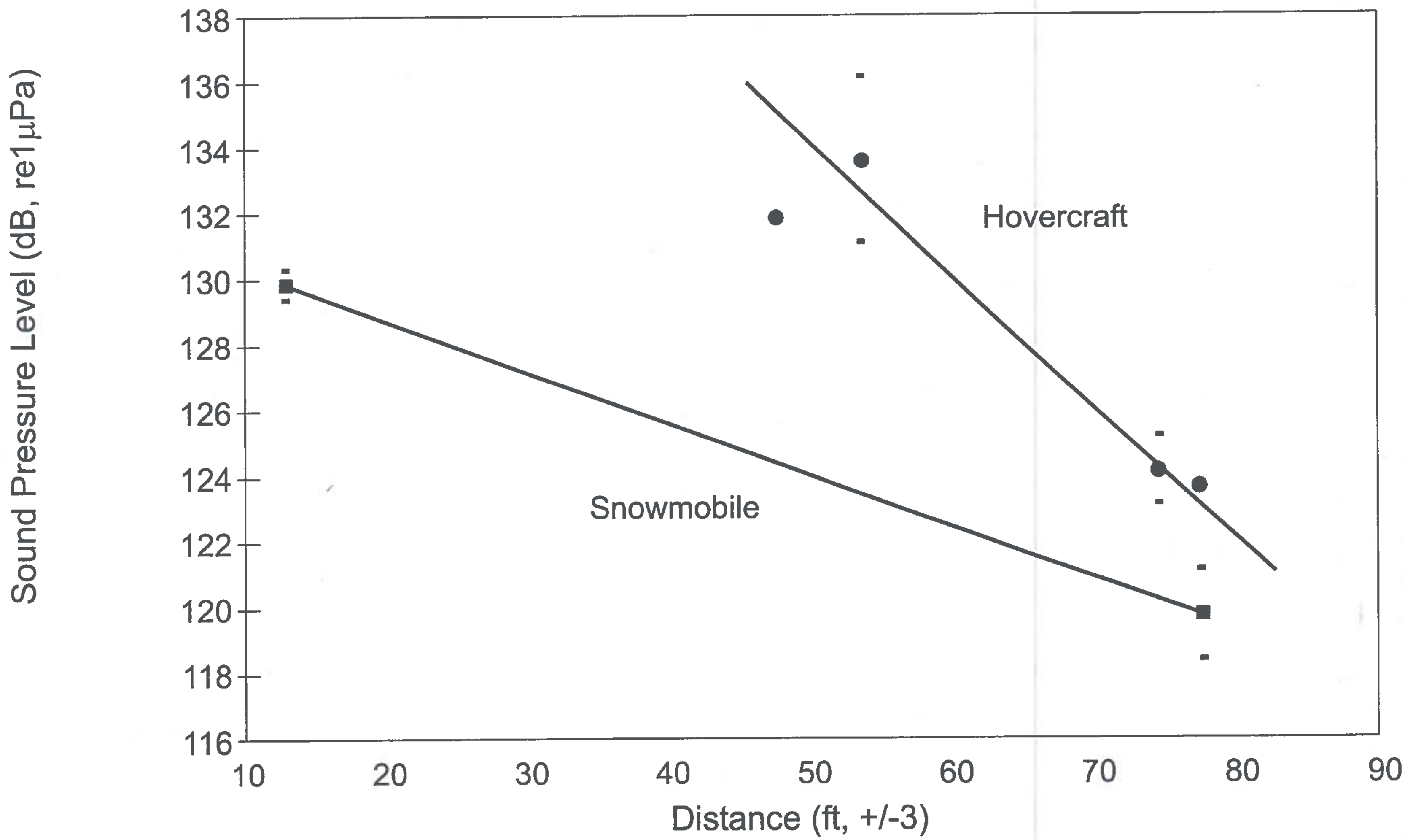
The results of these comparisons revealed that the hovercraft produces slightly more underwater sound than do snowmobiles at close distances. However, the maximum sound levels for hovercraft and snowmobiles converge with increasing distance from the source until there is no discernable difference at distances greater than 90 feet (Figure 3.11). At a distance of 90 feet, the total sound energy associated with a hovercraft pass appears slightly higher than that of a snowmobile (Figure 3.12), even though the maximum sound levels are about equal (Figure 3.11). This difference is likely due to the fact that the snowmobile events were typically less than 10 seconds in duration, whereas the hovercraft events tended to be at least 60 seconds.

Conclusions of Winter Subsistence Monitoring

The results of the field observations of blackfish behavior in response to the hovercraft revealed that blackfish sometimes slowly swan down away from the surface of the water within fishing holes when the hovercraft passed by, while at other times no reaction was apparent. In fact, the blackfish seemed to react more to ice being cleared from the hole, than they did to the hovercraft passing by. No reaction was observed when snowmobiles passed by.

The underwater sound measurements revealed that the hovercraft produced slightly greater underwater sound levels than did snowmobiles. A literature search failed to produce any specific auditory information regarding blackfish. However, species have different low and high-end thresholds for sound reception, but as a whole, the range is not all that great. The lateral line system in fish detects frequencies below 500 Hz. Since the blackfish displayed little reaction during the hovercraft pass-bys during which the sound measurements were being recorded, it seems that the sound levels produced by the hovercraft were at frequencies that have little effect on blackfish behavior.

Although blackfish sometimes swam downward when the hovercraft passed, they returned to the hole in similar numbers soon afterward, usually within 2 to 5 minutes. In addition, many blackfish actually swam into the trap during hovercraft passes, which would increase catch rates rather decreasing them. In conclusion, it appears that the hovercraft has no appreciable adverse effect on blackfish subsistence fishing during the winter on the Johnson River.



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Comparison Of Hovercraft and Snowmobile Maximum Underwater Sound Levels

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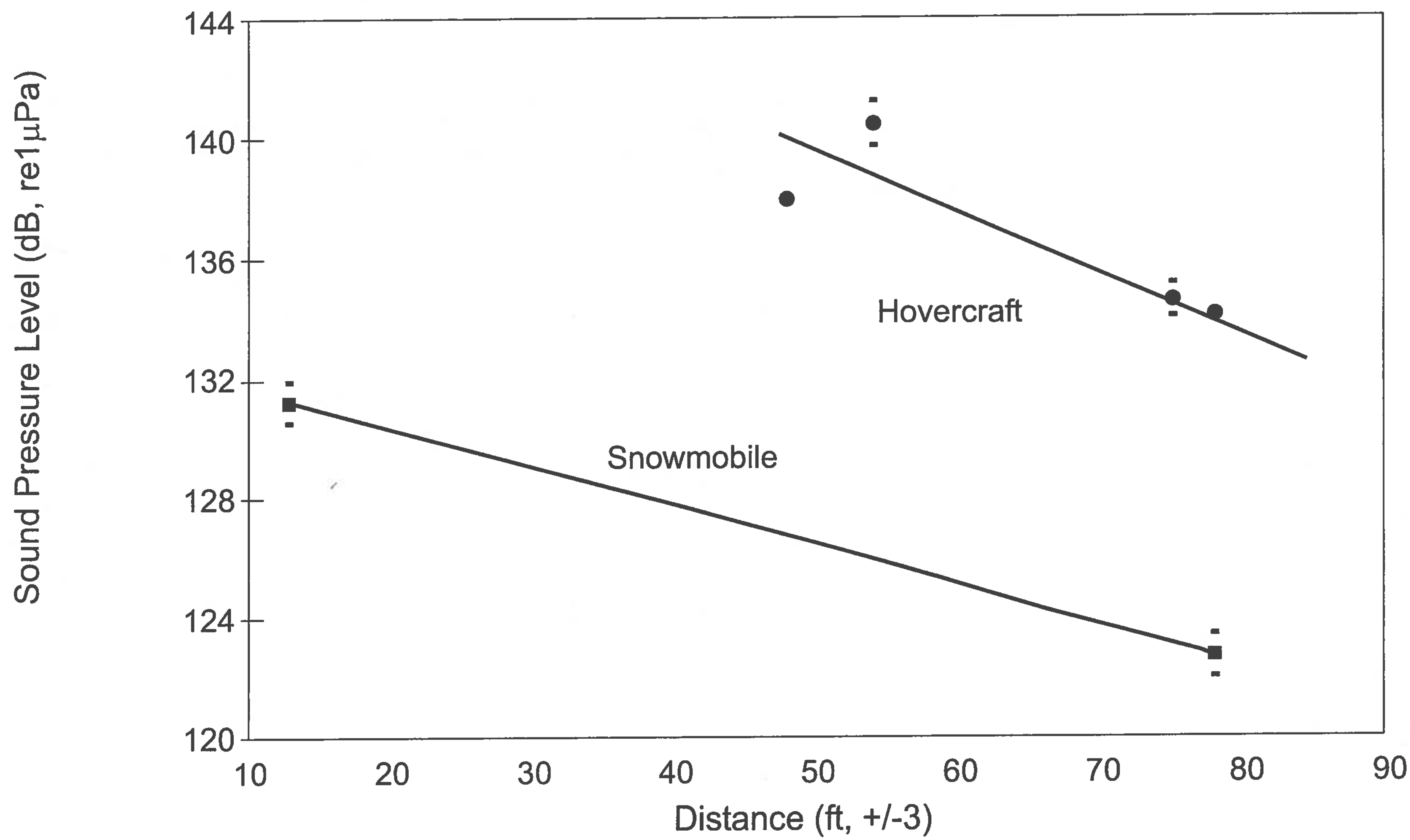
Figure 3.11



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Comparison Of Hovercraft and Snowmobile Underwater Sound Exposure Levels

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Figure 3.12

4.0 Summary and Conclusions

This report summarizes ecological monitoring data collected during the two-year Alaska Hovercraft Demonstration Project and presents the results of several studies related to potential hovercraft impacts. The issues addressed included:

- Is there a difference in behavioral responses of waterfowl to hovercraft versus other watercraft, and if so, what is the difference?
- Is the nesting success of waterfowl along the river routes of the hovercraft affected by the hovercraft's passage?
- Are adult fish being injured or killed by the hovercraft?
- Are juvenile fish being injured or killed by the hovercraft as it passes over shallow water?
- Do juvenile fish become stranded by the wake of the hovercraft in shallow areas of the rivers and if so, are they at greater risk than from conventional watercraft?
- Does the hovercraft impact subsistence fishing and, if so, in what manner?

The Alaska Hovercraft Ecological Monitoring Program was implemented during the Demonstration to evaluate the overall nature and extent of impacts, if any, from use of the hovercraft to fish, waterfowl, and subsistence efforts by answering these questions. The results clearly show that the hovercraft has a negligible influence on waterfowl and fish and that the effect does not adversely affect waterfowl and fish subsistence success in the area.

Both this monitoring program and the Hovercraft Committee were established to address public concerns that significant impact could result from hovercraft operations on the Kuskokwim and Johnson Rivers. Concern regarding impacts is elevated in this case because of the novelty of hovercraft operations on an Alaska river and because the waterfowl and fish in Alaska provide critical subsistence to local people.

During the Hovercraft Demonstration Project environmental review process, great care was taken to analyze potential environmental impacts and explain the hovercraft technology. The initial environmental review process concluded that there would be no significant adverse environmental impacts from the proposed Hovercraft Demonstration Project. Nonetheless, village elders and other community representatives feared the project would have a significant impact on waterfowl and fish. The US Postal Service addressed these concerns by conducting extensive monitoring during actual hovercraft operations to accumulate data that would clarify the potential impact of the project.

A summary of the data and results presented in this report follows.

4.1 Waterfowl Resources

The flushing responses of approximately over 9,000 birds, nearly half of which were waterfowl, were observed over four monitoring campaigns (1997 to 1998). Waterfowl, which are important subsistence animals, were found to flush almost 100 percent of the time in response to either the hovercraft or motorboat. Yet the fact that the waterfowl flush in response to the hovercraft does not mean a departure from the area.

To determine if breeding waterfowl or general waterfowl use of the area was being affected, during breeding season and later seasons, aerial surveys of bird use of rivers and nearby habitats were conducted. It was found that waterfowl numbers adjacent to the rivers were not affected by the presence of the hovercraft. Essentially, the same numbers of birds were found in the areas adjacent to where the hovercraft operated and in areas where it did not operate. Assuming the birds were available for breeding in the May season, the presence or absence of the hovercraft does not have a significant effect on breeding waterfowl nor on general use of habitat, thus there should be no effect on subsistence waterfowl hunting. It also follows that the hovercraft could not have an effect on egg gathering activities either, since it did not affect waterfowl use of habitats on, adjacent to, or off the rivers.

Additional studies were conducted in 1999 to compare waterfowl abundance along hovercraft routes with waterfowl abundance in reference areas. A total of 1,311 waterfowl were observed during motorboat surveys along the Kuskokwim, Johnson, and Pikmiktalik Rivers. The results of these observations indicated that the hovercraft is not affecting waterfowl abundance along the Kuskokwim and Johnson Rivers, as numbers observed were similar to those in reference areas. The results are also consistent with the aerial surveys.

The answers to the questions posed concerning waterfowl and waterfowl subsistence impacts are provided below:

- Is there a difference in behavioral responses of waterfowl to hovercraft versus other watercraft, and if so, what is the difference? **No difference was observed. Waterfowl flushed in similar amounts from the hovercraft and motorboats. Waterfowl did not alter their use of habitat nor the amount they used any particular habitat associated with the Kuskokwim and Johnson Rivers.**
- Is the nesting success of waterfowl along the river routes of the hovercraft affected by the hovercraft's passage? **No effect was observed. Based upon aerial and motorboat surveys of the Johnson and Kuskokwim Rivers, the hovercraft had no discernible effect on nesting success. The results are based upon the facts that waterfowl abundance during breeding season and later during brooding and rearing showed no relationship to hovercraft operational and non-operational areas on the rivers.**

4.2 Fish Resources

The hovercraft was followed by boat for a total of 263 miles on the Kuskokwim and Johnson Rivers during the seven monitoring campaigns from 1997 to 1999 in an effort to observe if the hovercraft's effect on adult fish mortality. No fish mortality or injury was observed after the hovercraft passed. Furthermore, the monitoring team observed no fish floating to the surface after the hovercraft passed while they were tending nets, completing stranding studies, and observing flushing birds. In addition, 3,690 miles of general observations for dead or injured fish were made by monitoring team members while traveling the Kuskokwim and Johnson Rivers during the 1999 monitoring. Only eight dead or injured fish were observed during the entire 1999 monitoring, none of which were freshly killed. None could be attributed to hovercraft operation.

Beach seining studies were conducted in 1999 to determine if the hovercraft could be injuring small juvenile fish in shallow water. The sampling was conducted at sites that were thought to have the greatest numbers of juvenile fish compared to other locations along the rivers. Thus, these sample locations should show the most significant impacts. A total of 87 beach seinings were conducted in 1999, including 49 test seinings (immediately after the hovercraft passed) and 38 control seinings on the Kuskokwim and Johnson Rivers. All captured fish were checked for injuries. Statistical tests comparing the rates of injury to fish captured in the test seines to those in control seines found no significant difference. Therefore, the evidence indicates that the hovercraft operation does not cause any significant degree of injury to juvenile fish in shallow areas; indeed, it is only 0.1 percent of the 11,000 fish present in a mile of beach, which is only 11 juvenile fish.

Although when near shore the hovercraft creates a slightly larger wave than do most motorboats, the larger wave does not result in significant stranding of fish. Fish stranding observations were conducted at hovercraft landing sites and at low-gradient beaches throughout the monitoring program. No stranded fish were observed on the beaches used for wake studies in May 1998, despite checking more than 13,000 yards of beach. However, 27 stranded fish were observed at beaches used for seining in 1999, or when the hovercraft stopped on a beach, where 7,405 yards of beach were checked. In addition, stranded fish were also observed at hovercraft landing sites immediately after the hovercraft docked. While only two stranded fish were found at hovercraft landing sites in 1998, 85 fish were found in 1999. The 85 fish observed were from a total of 73 landing events. These few stranded fish are insignificant and would not represent an impact on the population, particularly when based on the thousands of fish present in front of the landing areas (based on seine results). Although stranding of a few juvenile fish is occurring, the numbers are a small proportion of the large numbers of fish present that could be potentially affected. Thus, the magnitude is very small considering the large number of fish that could be affected. Furthermore, stranded fish would be eaten by predators, often instead of live fish in the water.

Subsistence fishing with nets is a central and critical part of the residents' lives along the Kuskokwim and Johnson Rivers. A total of 101 paired netting tests, including both set nets and drift nets, were conducted on the Kuskokwim and Johnson Rivers. No significant difference resulted between the number of fish caught when the hovercraft passed or did not pass the nets. The data shows that the hovercraft operations have no effect, negative or positive (scaring fish into the net), on subsistence fishing success.

In summary, the answers to the questions posed at the beginning of the monitoring of fish resources are:

- Are adult fish being injured or killed by the hovercraft? **No. No adult dead or injured fish were observed where the cause of harm was attributable to the hovercraft, despite considerable efforts to observe such a result.**
- Are juvenile fish being injured or killed by the hovercraft as it passes over shallow water? **Juvenile fish populations were not being significantly harmed based upon observations of injured fish attributable to the hovercraft after it was directed to pass by in shallow water.**
- Do juvenile fish become stranded by the wake of the hovercraft in shallow areas of the rivers, and if so, are they at greater risk than from conventional watercraft? **Juvenile fish were not stranded in significant numbers. Indeed, numbers of stranded fish from the hovercraft operating in shallow water areas or at landing sites are negligible when compared to the numbers of fish documented to be in the shallow water areas.**
- Does the hovercraft impact subsistence fishing and, if so, in what manner? **No. The hovercraft did not affect gillnet fishing success, nor did it have a significant effect on blackfish behavior that adversely affected fishing success.**

5.0 References

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APPENDICES

Appendix A – Aerial Survey Transect Coordinates

Appendix A - Aerial Survey Transect Coordinates

H	IDNT	ZONE	EASTING	NORTHING	IDNT	LATITUDE (N)	LONGITUDE (W)
1	C1W	04V	386127	6763876	C1W	605942.6	1610618.9
1	C1E	04V	390128	6763876	C1E	605946.7	1610152.9
2	C2E	04V	389928	6762676	C2E	605907.8	1610203.7
2	C2W	04V	385927	6762676	C2W	605903.7	1610629.6
3	C3W	04V	385627	6761876	C3W	605837.5	1610647.9
3	C3E	04V	389628	6761876	C3E	605841.6	1610222.0
4	C4E	04V	389127	6760876	C4E	605808.8	1610253.2
4	C4W	04V	385128	6760876	C4W	605804.7	1610718.9
5	C5N	04V	383128	6760376	C5N	605746.4	1610930.7
5	C5S	04V	383127	6756376	C5S	605537.3	1610922.0
6	C6E	04V	382228	6756376	C6E	605536.3	1611021.7
6	C6W	04V	378228	6756376	C6W	605531.9	1611447.1
7	K2S	04V	368628	6744076	K2S	604843.7	1612454.0
7	K2N	04V	368627	6748076	K2N	605052.9	1612503.7
8	K1E	04V	373127	6752876	K1E	605333.1	1612017.2
8	K1W	04V	369128	6752876	K1W	605328.5	1612442.3
9	K3E	04V	367627	6752876	K3E	605326.7	1612621.7
9	K3W	04V	363627	6752876	K3W	605321.8	1613046.8
10	K4E	04V	356877	6745876	K4E	604927.2	1613755.4
10	K4W	04V	352877	6745876	K4W	604922.0	1614219.9
11	K5E	04V	353877	6738376	K5E	604521.2	1614053.5
11	K5W	04V	349878	6738376	K5W	604515.8	1614517.4
12	K6W	04V	348877	6737876	K6W	604458.3	1614622.0
12	K6E	04V	352877	6737876	K6E	604503.7	1614158.1
13	K7S	04V	341600	6731200	K7S	604106.6	1615336.1
13	K7N	04V	341600	6735200	K7N	604315.7	1615347.6
14	J9E	03V	661000	6730000	J9E	604030.2	1620309.9
14	J9W	03V	657000	6730000	J9W	604035.9	1620733.1
15	J8E	03V	657000	6734000	J8E	604245.0	1620721.5
15	J8W	03V	653000	6734000	J8W	604250.6	1621145.1
16	J7W	03V	652500	6735000	J7W	604323.6	1621215.2
16	J7E	03V	656500	6735000	J7E	604318.0	1620751.6
17	P5E	03V	658800	6739000	P5E	604523.9	1620508.3
17	P5W	03V	654800	6739000	P5W	604529.5	1620932.2
18	J6E	03V	653500	6739500	J6E	604547.5	1621056.6
18	J6W	03V	649500	6739500	J6W	604552.9	1621520.5
19	J5E	03V	651000	6741500	J5E	604655.5	1621336.0
19	J5W	03V	647000	6741500	J5W	604700.9	1621800.1
20	J4W	03V	644800	6743000	J4W	604745.6	1622021.5
20	J4E	03V	648800	6743000	J4E	604740.3	1621557.3
21	P4W	03V	651000	6744000	P4W	604816.2	1621329.0
21	P4E	03V	655000	6744000	P4E	604810.6	1620904.7
22	P3E	03V	655000	6744750	P3E	604834.9	1620902.6
22	P3W	03V	651000	6744750	P3W	604840.4	1621326.9
23	P2W	03V	651250	6746250	P2W	604928.5	1621306.2
23	P2E	03V	655250	6746250	P2E	604922.9	1620841.7
24	P1E	03V	655000	6746500	P1E	604931.3	1620857.5
24	P1W	03V	651000	6746500	P1W	604936.9	1621322.0
25	J2E	03V	643500	6750500	J2E	605156.0	1622127.3
25	J2W	03V	639500	6750500	J2W	605201.2	1622552.1
26	J3E	03V	636000	6751500	J3E	605237.8	1622941.4
26	J3W	03V	632000	6751500	J3W	605242.7	1623406.3
27	J1W	03V	637000	6753000	J1W	605325.0	1622831.3
27	J1E	03V	641000	6753000	J1E	605320.0	1622406.2
W	P106E	03V	650596	6752384	P106E	605240.8	1621332.4
W	P106W	03V	643156	6753228	P106W	605317.9	1622143.0
W	P108E	03V	652302	6748994	P108E	605049.0	1621149.0
W	P108W	03V	646512	6749539	P108W	605114.4	1621810.7
W	P110E	03V	648549	6744864	P110E	604840.8	1621608.7
W	P110W	03V	642737	6745670	P110W	604914.5	1622230.8
W	P112E	03V	653119	6739400	P112E	604538.2	1621122.2
W	P112W	03V	647367	6740385	P112W	604617.8	1621739.1

Appendix B – Statistical Analyses

Appendix B – Statistical Analyses

Habitat Analysis

The Mann-Whitney *U* test is the nonparametric version of the two group unpaired *t*-test that is resistant to outliers in the groups being compared. Nonparametric tests are used when the underlying distribution of the data does not meet the assumptions for parametric tests (such as not meeting the assumptions for normality of the data or having small sample sizes). Where parametric tests estimate the parameters of the hypothesized distribution and uses these estimates for computations, nonparametric tests use alternatives such as sequential ranking of observations (or variables) of interest. In the case of the habitats, not all the data were normally distributed, so this parametric test could not be used. However, they met the requirements for the Mann-Whitney *U* test. That is, the two groups came from continuous distributions and the observations were independent of each other.

Analysis of Waterfowl Abundance along Rivers

The Kruskal-Wallis one-way analysis of variance (ANOVA) is a non-parametric test that compares several different groups by ranking all values in the data set without regard to which group they are in, and then comparing the sum of the ranks for each group. The advantage of using this test is that the data do not have to meet the assumptions of parametric statistics to be compared (as described above). ANOVA is used when comparing more than two groups of data. When a significant difference is indicated by the ANOVA there is a significant differences among the groups. However, a mean separation to discern individual differences among the data. The method used to discern differences among the waterfowl abundance data was the Dunn's multiple pairwise comparison method. This method allows individual pairwise comparisons of the different groups in the ANOVA to test for significant differences between groups.

Wake Analysis

The student's t-test and analysis of variance were used to discern significant differences in the wake characteristics among the hovercraft, motorboats, and tugs/barges. These tests were used because the data were normally distributed and continuous, and as such did not require the use of non-parametric statistics.

Gillnetting Analysis

Data were statistically evaluated using the Wilcoxon paired sign rank test, which is a nonparametric alternative to the paired Student's t-test. The test compares signed ranks of the differences between control and test data in a paired design. The absolute value of the differences between the observed values (fish caught) of the test and control were ranked in ascending order. Ties were given a value equal to the mean sum of ranks for the tie group (i.e., the sequential ranks for each tie number is added up and divided by that number of tie in that group). For example, if there are 5 occurrences of differences with a value of 1, the applied rank of each would be $(1+2+3+4+5)/5 = 3$. After ranking, the sign of the difference is assigned to the ranks. The sum of the ranks of the less frequent sign is the test statistic T, which is compared to critical T values that are obtained from reference tables. Test T values larger than the critical T value result in rejection of the null hypothesis that there is a difference between treatments for the selected probability (0.05).

The Chi-square test originally proposed in the study permit application was not used because of the high number of pairs where no fish were caught. This phenomenon, which was not expected, undoubtedly a result of the short net sets and inexperience in fishing on the subject rivers, resulted in a violation of the requirements of the Chi-square. The signed Wilcoxon paired test is not adversely affected by pairs of zeros or numerous ties and allows those data to be used in the test if desired.

Chi-Square Contingency Table Analysis

The Chi-square contingency table analysis is a statistical technique used to test if variables are independent or dependent. In the case of the beach seining data, the purpose of the tests was to determine if the proportion of dead/injured fish caught during sampling was independent of or dependent on whether the sample was collected from a test or control set. The null hypothesis (hypothesis being tested) in this case was that the proportion of dead / injured fish caught was independent of whether or not the hovercraft had passed through the sampling area (test sets).

The Chi-square statistic is calculated by summing the values obtained by squaring the observed values minus expected values, divided by the expected values (Equation 1). The expected values are calculated by multiplying each row total of the contingency table by the column total and dividing by the grand total of all observations in the contingency table. The Chi-square statistic or sum of these calculated values is then compared with a critical value obtained form Chi-square statistic tables. If the calculated Chi-square statistic (χ^2) exceeds the critical value, then the null hypothesis is rejected, thus indicating that the variables are not independent.

$$\chi^2 = \sum \frac{(\text{Observed value} - \text{Expected value})^2}{\text{Expected value}}$$

Appendix C – Wake Events Measured During 1998

Appendix C - Wake Events Measured during 1998

Wave Data

						Craft Characteristics					Wake Characteristics			
Station	Date	Time	River Stage	Tide Stage (ft)	Obs	Type	Ln. (ft)	Hp	Sp	Dist	Crest Ht. (in)	Surge Ht. (in)	Surge Dist. (ft)	Photo #
MAY														
05/18/1998	KS-1	10:10			SP	Photo 1	18	100	25	1500	1	0.5	2	1
05/18/1998	KS-1	10:19			SP	Hovercraft				1500	6	2	6	5&6
05/18/1998	KS-1	15:10			PV	Boat				200	3	0.5	2	
05/18/1998	KS-1	15:16			PV	Hovercraft & Boat				200	7	3	4	
05/18/1998	KS-1	15:28			PV	Boat				200	1	0.5	1	19
05/18/1998	KS-1	15:32			PV	Boat				200	1	0.5	1	
05/18/1998	KS-1	15:43			PV	Boat				200	2	0.25	0.5	
05/18/1998	KS-1	15:46			PV	Boat				200	4	1	3	
05/18/1998	KS-1	15:58			PV	Boat				200	2	0.5	1	
05/18/1998	KS-1	16:00			PV	2 Boats				200	9	3	7	20
05/18/1998	KS-1	16:08			PV	Hovercraft				200	6	1.5	5	
05/18/1998	KS-3	16:50			RW	Tug/Barge	60?	?	10	400	3	1.5	3	
05/18/1998	KS-3	17:00			RW	Antone	20	90	30	100	4	2	2	
05/18/1998	KS-3	17:05			RW	Antone	20	90	15	60	8	2	3	
05/18/1998	KS-3	17:10			RW	Antone	20	90	10	150	6	2	3	
05/18/1998	KS-3	17:15			RW	Antone	20	90	20	200	8	2.5	4	
05/18/1998	KS-3	17:19			RW	Skiff	18	40	20	300				
05/19/1998	JS-1	10:40			SP	Hovercraft			15	300	3	1	1	13
05/19/1998	KS-1	15:24			PV	Boat	15		20	200	2	0.5	2	
05/19/1998	KS-1	15:46			PV	Lund			30	700	2	0.5	1	
05/19/1998	KS-1	15:48			PV	Boat			20	500	3	0.5	2	
05/19/1998	KS-1	15:50			PV	Boat	20		15	200	4	1	3	
05/19/1998	KS-1	15:53			PV	Lund			12	800	2	0.5	0.5	
05/19/1998	KS-1	16:02			PV	Boat	15		20	100	4	0.5	1	
05/19/1998	KS-1	16:05			PV	Lund			25	500	3	0.5	1	
05/19/1998	KS-1	16:12			PV	Lund			20	200	4	1	2	
05/19/1998	KS-1	16:13			PV	Boat	15		15	500	3	0.5	1	
05/19/1998	KS-1	16:14			PV	Lund	15		15	800				
05/19/1998	KS-1	16:20			PV	Boat	20		15	1000	2	0.25	0.5	
05/19/1998	KS-1	16:29			PV	Boat	15		20	1000	2	0.25	0.5	
05/19/1998	KS-1	16:35			PV	Lund			25	500	3	0.5	2	
05/19/1998	KS-3	15:35			RW	Lund	18	40	25	600				
05/19/1998	KS-3	16:00			RW	Woolridge	20	100	35	600				
05/19/1998	KS-3	16:02			RW	Skiff	18	40	30	600				
05/19/1998	KS-3	16:09			RW	Lund	16	35	20	100	3	0.5	1	
05/19/1998	KS-3	16:13			RW	Skiff	18	40	30	500	6	0.5	1	
05/19/1998	KS-3	16:19			RW	Skiff	18	40	25	100	3	0.5	1	
05/19/1998	KS-3	16:25			RW	Skiff	16	25	25	50	3	0.5	1	
05/19/1998	KS-3	16:42			RW	Woolridge	20	100	25	400				
05/20/1998	KS-2	9:19			PV	Antone				200	4	1	1	
05/20/1998	KS-2	9:24			PV	Boat				200	3	0.5	0.5	
05/20/1998	KS-2	9:53			PV	Boat	15			200	3	0.5	1	
05/20/1998	KS-2	10:17			PV	Hovercraft				50	7	2.5	3	30
05/20/1998	KS-3	12:13			PV	John			20	400	3	0.5	0.5	
05/20/1998	KS-3	12:20			PV	John			25	600	4	1.5	2	
05/20/1998	KS-3	12:53			PV	Hovercraft			30	50	9	3	6	31
05/20/1998	KS-3	13:24			PV	Lund			20	600	3	0.5	1	
05/20/1998	KS-3	14:03			PV	Boat	20		20	400	3	0.5	1	
05/20/1998	KS-3	14:26			PV	John			15	300	3	0.1	1	
05/20/1998	KS-3	14:32			PV	John			20	400	4	1	3	
05/20/1998	KS-3	14:32			PV	Antone			20	300	5	1.5	4	
05/20/1998	KS-3	14:42			PV	Skiff	20		12	300	4	1	3	
05/20/1998	KS-3	14:54			PV	Antone				200				
05/20/1998	KS-3	14:56			PV	Hovercraft				50	24	3	7	32
05/20/1998	KS-3	15:16			PV	John			20	200	4	1	2.5	
05/20/1998	KS-3	15:20			PV	Boat	20		15	300	3	0.5	1	
05/20/1998	KS-3	15:26			PV	John			20	200	3	0.5	1	
05/20/1998	KS-3	16:00			PV	Lund			10	800	2	0.5	2	
05/20/1998	KS-3	16:05			PV	Hovercraft				70	9	2	4	33
05/21/1998	JS-1	10:16			PV	Boat				30	6	2	3	
05/21/1998	JS-1	10:20			PV	Boat			15	20	4	1.5	2	
05/21/1998	JS-1	11:18			PV	Hovercraft				8	20	9	6	
05/21/1998	JS-1	11:21			PV	Boat			15	50	4	1.5	2	
05/21/1998	JS-1	12:04			PV	John			24	100	5	2	2	
05/21/1998	JS-1	12:06			PV	Lund			15	30	4	0.5	1	
05/21/1998	JS-1	12:06			PV	John			24	150	5	1	1	
05/21/1998	JS-1	12:15			PV	Boat	20		20	80	4	0.5	0.5	
05/21/1998	JS-1	12:50			PV	John	25		24	100	4	1	0.25	
05/21/1998	JS-1	12:53			PV	John	20		20	80	4	1	0.5	
05/21/1998	JS-1	13:17			PV	Hovercraft				15	18	4	3	
05/21/1998	JS-1	13:20			PV	John				50	4	2	1	
05/21/1998	JS-1	15:27			PV	Boat	20		20	100	3	0.5	0.5	
05/21/1998	JS-1	15:31			PV	Boat	20		24	150	2	0.5	0.5	
05/22/1998	KS-3	9:34	Low		PV	Boat	14		15	100	4	1.5	1	
05/22/1998	KS-3	9:39			PV	Boat	20		15	200	3	2	2	

Appendix C - Wake Events Measured during 1998

Wave Data						Craft Characteristics					Wake Characteristics			
Station	Date	Time	River Stage	Tide Stage (ft)	Obs	Type	Ln. (ft)	Hp	Sp	Dist	Crest Ht. (in)	Surge Ht. (in)	Surge Dist. (ft)	Photo #
05/22/1998	KS-3	10:11			PV	Hovercraft			25/30	80	24	3.5	6	35
05/22/1998	KS-2	11:58			PV	Boat	15		20	200	4	1	3	
05/22/1998	KS-2	12:02			PV	Boat	20		20	200	3	0.5	2	
05/22/1998	KS-2	12:28			PV	John			25	200	3	0.5	1.5	
05/22/1998	KS-2	12:30			PV	John			10	500	2	0.5	1	
05/22/1998	KS-2	12:40			PV	Hovercraft			30	70	26	4	6	
05/22/1998	KS-2	12:41			PV	John			24	300	4	1.5	4	
05/22/1998	KS-3	13:10			PV	Boat			20	150	4	2	3	
05/22/1998	KS-3	13:26			PV				20	100	3	1	2	
05/22/1998	KS-3	13:38			PV	Boat	20		20	100	3	0.5	2	
05/22/1998	KS-3	13:38			PV	Boat				70	3	1	2	
05/22/1998	KS-3	13:41			PV	Boat	20		400	100	3	0.5	2	
05/22/1998	KS-3	13:43			PV	Boat	20		22	200	4	2	4	
05/22/1998	KS-3	13:50			PV	Boat	20		15	50	3	1.5	2	
05/22/1998	KS-3	13:56			PV	Lund			20	50	3	1	2	
05/22/1998	KS-3	13:57			PV	Lund			20	30	3	1.5	3	
05/22/1998	KS-3	13:57			PV	Boat	20		24	100	2.5	1	1	
05/22/1998	KS-3	14:06			PV	Boat			10	500	5	3	5	
05/22/1998	KS-3	14:06			PV	Lund			10	100	1	2	4	
05/22/1998	KS-3	14:13			PV	Lund	20		20	300	3	0.5	1	
05/22/1998	KS-3	14:22			PV	Boat	20		20	100	2	0.5	2	
05/22/1998	KS-3	14:32			PV	Boat	20		20	100	3	1	4	
05/22/1998	KS-3	14:33			PV	Lund	75		15	900	4	1.5	5	
05/22/1998	KS-3	14:45			PV	Boat	15		10	800	2	1	2	
05/22/1998	KS-3	14:48			PV	Boat	20		20	100	3	1	3	
05/23/1998	Napakiak South	10:13			PV	Hovercraft			30	30	24	4	10	1
05/23/1998	Napakiak South	11:56			PV	Boat			20	1500				
05/23/1998	Napakiak South	12:08			PV	Boat	20		20	500				
05/23/1998	Napakiak South	12:10			PV	Boat	20		20	200				
05/23/1998	Napakiak South	12:39			PV	Lund				2500				
05/23/1998	Napakiak South	12:47			PV	Boat	20		20	200				
05/23/1998	Napakiak South	13:06			PV	Boat	20		20					
05/23/1998	Napakiak North	13:44			PV	Boat	20		20	2500				
05/23/1998	Napakiak North	13:48			PV	1 Pilot, 1 Tug, 1 Barge, 1 Freight			10	1500				1-4
05/23/1998	Napakiak North	14:18			PV	?				200				
05/23/1998	Napakiak North				PV	?				200				
05/23/1998	Napakiak North	14:24			PV	Boat	20		15	1000				
05/23/1998	Napakiak North	14:29			PV	Hovercraft			35	500	4	1	Tide	
										112				
JULY														
07/08/1998	K-2	14:32	High	High	RW	Alum. River	20	90	20	600	2	0.5	1	
07/08/1998	K-2	14:50	High	High	RW	Alum. River	20	90	30	700				
07/08/1998	K-2	15:21	High	High	RW	Alum. River	20	90	25	100	5	1.5	1	
07/08/1998	K-2	15:28	High	High	RW	Aluminum	16	40	20	700	2	0.5	1	
07/08/1998	K-2	16:04	High	High	RW	Tug/Barge	100	?	10	1800	1	0.5	1	
07/09/1998	KS-2	10:59	Low	Low	PV	John			7	30	1.5	1.5	1	
07/09/1998	KS-2	11:13				John			27	25	3	1	1.5	
07/09/1998	KS-2	11:26				John			5	50	1	0.5	0.5	
07/09/1998	KS-2	11:31				John			20	150	3	1	1	
07/09/1998	KS-2	11:51				John			5	200	1	0.25	0.25	
07/09/1998	KS-2	11:55				John			28	150	2	1	1	
07/09/1998	KS-3	12:50				Lund			25	100	2	1	1	
07/09/1998	KS-3	12:52				Lund			20	70	3	1	2	
07/09/1998	KS-3	13:06				Lund			20	40	3.5	1	1.5	
07/09/1998	KS-3	13:14				MB	15		28	50	3	1	1	
07/09/1998	KS-3	13:27				John			28	80	3.5	1	1.5	
07/09/1998	KS-3	13:29				John			28	30	4.5	1.5	3	
07/09/1998	KS-3	13:33				Lund			20	40	3	1	2	
07/09/1998	KS-3	13:50				MB	20		15	100	2	1	1	
07/09/1998	KS-3	14:00				John			25	200	3	1	2.5	
07/09/1998	KS-3	14:04				John				50	4	1.5	3	
07/09/1998	KS-3	14:14				John			5	30	4	1	2	
07/09/1998	KS-3	14:17				John			15	200	2	1	2	

Appendix C - Wake Events Measured during 1998

Wave Data

						Craft Characteristics					Wake Characteristics			
Station	Date	Time	River Stage	Tide Stage (ft)	Obs	Type	Ln. (ft)	Hp	Sp	Dist	Crest Ht. (in)	Surge Ht. (in)	Surge Dist. (ft)	Photo #
07/09/1998	KS-3	14:25				MB	20		20	100	2	1	1.5	
07/09/1998	KS-3	14:27				MB	15		25	150	1	0.5	1	
07/09/1998	KS-1	14:37				Barge	80		10	500	3	1	2	
07/09/1998	KS-1	14:39				Lund			25	700				
07/09/1998	KS-1	14:49				Lund			25	400	0.5	2.25	0.5	
07/09/1998	KS-1	14:54				MB	15		25	500	1	0.5	1	
07/09/1998	KS-1	14:55				MB	15		25	500				
07/09/1998	KS-1	15:01				MB	15		30	400	2	1	2	
07/09/1998	KS-1	15:01				Fishing Boat	25		20	200	4	2	4	
07/09/1998	KS-1	15:03				MB	20		25	400	1	1	2	
07/09/1998	KS-1	15:15				MB	15		20	600				
07/09/1998	KS-1	15:15				MB	15		15	400	2	1	2	
07/09/1998	KS-1	15:16				MB	15		15	500	4	2	5	
07/09/1998	KS-1					MB	15		20	500				
07/09/1998	KS-1	15:17				MB	15		15	600				
07/09/1998	KS-1	15:28				MB	15		15	700	1	1	1.5	
07/09/1998	KS-1	15:31				Lund			15	600	1	1	1	
07/09/1998	KS-1	15:34				John			15	100	3	1.5	3	
07/09/1998	KS-1	15:35				John			28	300	4	2	4	
07/09/1998	KS-1	15:38				MB	20		20	500	1.5	1	1	
07/10/1998	KS-3	13:11		Out	SP	OB	16			150	3	1	1.5	
07/10/1998	KS-3	13:12			SP	OB	16		20	200	3	1	1.5	
07/10/1998	KS-3	13:18			SP	OB	16		20	100	3	1	2	
07/10/1998	KS-3	13:47			SP	OB	16		25	800	3	1	1	
07/10/1998	KS-3	13:48			SP	OB	16		10	100	3	2	3	
07/10/1998	KS-3	13:52			SP	OB	16		20	700	2	1	1	
07/10/1998	KS-3	13:57			SP	OB	16		20	300	2	1	2	
07/10/1998	KS-3	13:59			SP	OB	16		15	400	2	1	2	
07/10/1998	KS-3	14:03			SP	OB	16		15	100	3	1	2	
07/10/1998	KS-3	15:01		Flooding	RW	Tug/Barge	40/100		10	400	3	2	2.5	

Appendix D – Beach Seining and Beach Stranding Data (1999)

Appendix D Beach Seining and Beach Stranding Data (1999)

Month	Date	River	Location	Set Type (test/control)	Time of Hovercraft Passage	Time of Seining	Length of Beach Checked (yds)	No. of Stranded Fish Found	No. Stranded Fish per Yard of Beach Checked	Stranded Fish Species	chum D	chum I	chum U	whitefish (0+) D	whitefish (0+) I	whitefish (0+) U	whitefish (1+) D	whitefish (1+) I	whitefish (1+) U	sucker D	sucker I	sucker U	sculpin D	sculpin I	sculpin U	sheefish D	sheefish I	sheefish U	stickleback D	stickleback I	stickleback U	pike (0) D	pike (0) I	pike (0) U	pike (+3) D	pike (+3) I	pike (+3) U	coho D	coho I	coho U	lamprey D	lamprey I	lamprey U	burbot D	burbot I	burbot U	pink D	pink I	pink U	king D	king I	king U	smelt D	smelt I	smelt U	blackfish D	blackfish I	blackfish U
August	08/16/1999	Kuskokwim	BSK-6	test	14:50	14:55	100	0	0										31			18			5																																	
August	08/17/1999	Kuskokwim	BSK-6	test	16:05	16:07	200	0	0							5			1			6			2																																	
August	08/17/1999	Kuskokwim	BSK-6	test	14:34	14:36	200	1	0.005	whitefish					1	15					2	10			7																																	
August	08/17/1999	Kuskokwim	BSK-5	test	12:44	12:46	300	0	0							7						38			19																																	
August	08/17/1999	Johnson	BSJ-3	test	12:23	12:26	Not Checked	No Data								2										3	3	847			12			2																								
August	08/17/1999	Johnson	BSJ-3	control	NA	10:55	Not Checked	No Data								6										9		1060			20																						9		5			
August	08/17/1999	Johnson	BSJ-1	test	9:53	9:56	Not Checked	No Data								8												309			9																						1		6			
August	08/17/1999	Kuskokwim	BSK-6	control	NA	13:58	Not Checked	No Data						1	1	54						29			2																																	
August	08/18/1999	Kuskokwim	BSK-4	test	9:30	9:32	200	0	0							1						2																					1															
August	08/18/1999	Kuskokwim	BSK-5	control	NA	10:35	Not Checked	No Data								8				1		6			36																																	
August	08/18/1999	Kuskokwim	BSK-5	control	NA	not recorded	Not Checked	No Data								4						2			8									1																								
August	08/20/1999	Kuskokwim	BSK-5	control	NA	11:20	Not Checked	No Data								1			5			1			10																																	
August	08/20/1999	Kuskokwim	BSK-4	control	NA	9:25	Not Checked	No Data								80						61			4																																	
August	08/20/1999	Kuskokwim	BSK-4	test	9:53	9:55	200	0	0							25			1			28			2																																	
August	08/20/1999	Kuskokwim	BSK-5	test	13:06	13:08	Not Checked	No Data																										1																								
August	08/20/1999	Kuskokwim	BSK-6	test	14:12	14:14	150	0	0							157			101			9																																				
August	08/20/1999	Kuskokwim	BSK-6	test	14:38	14:40	175	0	0							34						2																																				
August	08/20/1999	Kuskokwim	sandbar*	NA*	NA	NA	80	11	0.1375	sucker																																																
August	08/20/1999	Kuskokwim	sandbar*	NA*	NA	NA	80	0	0																																																	
August	08/21/1999	Johnson	BSJ-3	control	NA	10:18	Not Checked	No Data								3										1	2	89			13																											
August	08/21/1999	Johnson	BSJ-2	test	14:17	14:19	Not Checked	No Data																				53			21																											
August	08/21/1999	Johnson	BSJ-2	control	NA	12:13	Not Checked	No Data																				117			10																											
August	08/21/1999	Johnson	BSJ-3	test	11:08	11:10	Not Checked	No Data																		1		74			19			1																								
August	08/21/1999	Johnson	BSJ-3	control	NA	10:18	Not Checked	No Data								3										1	2	89			13																											
Totals							7405	59	0.0073		18	0	1042	35	14	3166	1	0	192	1	2	619	2	1	309	84	43	3046	0	0	237	0	0	78	0	0	2	0	0	3	0	0	11	0	0	10	0	0	5	0	1	0	11	0	21	0	0	1

Notes: * Observations of fish strandings when the hovercraft made unplanned stops on beaches
D = Dead
I = Injured
U = Unharmed
Total Number of Stranded Fish per Yard of Beach Checked is the "Average Number per Yard of Beach Checked"

Data below were not included in analysis for reasons listed.

Month	Date	River	Location	Set Type (test/control)	Time of Hovercraft Passage	Time of Seining	Length of Beach Checked (yds)	No. of Stranded Fish Found	No. Stranded Fish per Yard of Beach Checked	Stranded Fish Species	chum D	chum I	chum U	whitefish (0+) D	whitefish (0+) I	whitefish (0+) U	whitefish (1+) D	whitefish (1+) I	whitefish (1+) U	sucker D	sucker I	sucker U	sculpin D	sculpin I	sculpin U	sheefish D	sheefish I	sheefish U	stickleback D	stickleback I	stickleback U	pike (0) D	pike (0) I	pike (0) U	pike (+3) D	pike (+3) I	pike (+3) U	coho D	coho I	coho U	lamprey D	lamprey I	lamprey U	burbot D	burbot I	burbot U	pink D	pink I	pink U	king D	king I	king U	smelt D	smelt I	smelt U	blackfish D	blackfish I	blackfish U	Remarks
June	06/16/1999	Kuskokwim	BSK-2	test	12:58	13:02					29		43									4	4		5																																		**Bad set: net full of mud caused asphyxiation of fish**
June	06/22/1999	Johnson	BSJ-1	control	NA	10:08	Not Checked	No Data																																																		**No fish caught**
July	07/09/1999	Kuskokwim	BSK-6	test	14:52	14:55	Not Checked	No Data						94		55			2			70						1						1																									**Mortality from asphyxiation in bucket (alive when placed in bucket)**
July	07/10/1999	Johnson	BSJ-2	test	14:15	14:17	Not Checked	No Data																																																			**No fish caught**
July	07/13/1999	Johnson	BSJ-3	test	13:22	13:25	200	0						27	2	107															7																												**Bad set: boat wake caused net to roll up, resulting in unrelated mortlaity**
August	08/14/1999	Kuskokwim	BSK-2	test	10:55	10:57	Not Checked	No Data								4										640	14	760			61																												**Bad set: fish just post-larval, very warm water, caused high mortality**
August	08/14/1999	Johnson	BSJ-2	control	NA	10:23	Not Checked	No Data								3										267	85	902			1																												**Bad set: fish just post-larval, very warm water, caused high mortality**
August	08/20/1999	Kuskokwim	BSK-5	test	13:02	13:05	Not Checked	No Data											1																																								**Bad set: high tide prevented enclosure of net, fish escaped**

Appendix D Beach Seining and Beach Stranding Data (1999)

Month	Date	River	Location	Set Type (test/control)	Time of Hovercraft Passage	Time of Seining	Length of Beach Checked (yds)	No. of Stranded Fish Found	No. Stranded Fish per Yard of Beach Checked	Stranded Fish Species	chum			whitefish (0+)			whitefish (1+)			sucker			sculpin			sheefish			stickleback			pike (0)			pike (+3)			coho			lamprey			burbot			pink			king			smelt			blackfish		
											D	I	U	D	I	U	D	I	U	D	I	U	D	I	U	D	I	U	D	I	U	D	I	U	D	I	U	D	I	U	D	I	U	D	I	U	D	I	U	D	I	U	D	I	U	D	I	U
June	06/16/1999	Kuskokwim	BSK-1	test	10:02	10:05	Not Checked	No Data			1		4			1																											4															
June	06/16/1999	Kuskokwim	BSK-3	control	NA	14:00	Not Checked	No Data					26	1		2							1																																		
June	06/17/1999	Kuskokwim	BSK-2	control	NA	14:00	Not Checked	No Data			12		29	5		11						3	1		8																																
June	06/17/1999	Kuskokwim	BSK-4	control	NA	15:30	Not Checked	No Data					24			1																																									
June	06/18/1999	Kuskokwim	BSK-5	test	13:30	13:32	200	4	0.02	chum			46			1						1			2																																
June	06/18/1999	Kuskokwim	BSK-4	control	NA	15:07	Not Checked	No Data			2		49	1		4																																									
June	06/18/1999	Kuskokwim	BSK-4	test	10:00	10:01	200	0	0		2		149	3		7									2																																
June	06/18/1999	Man-made slough*		NA*	NA	NA	80	0																																																	
June	06/19/1999	Johnson	BSJ-2	control	NA	13:04	Not Checked	No Data					9			3									2						3																									1			
June	06/19/1999	Johnson	BSJ-2	test	15:33	15:35	325	0	0				1																		3																									1			
June	06/19/1999	Johnson	BSJ-1	test	11:06	11:08	175	0	0				2																		4																												
June	06/21/1999	Kuskokwim	BSK-4	control	NA	9:40	Not Checked	No Data					142			26			3																					1													1						
June	06/21/1999	Kuskokwim	BSK-6	control	NA	13:41	Not Checked	No Data					92			28						2																																			
June	06/21/1999	Kuskokwim	BSK-6	test	15:15	15:17	Not Checked	No Data					6			10																																	1								
June	06/21/1999	Kuskokwim	BSK-6	test	16:32	16:34	200	1	0.005	whitefish			150			44			1			3																																			
June	06/21/1999	Kuskokwim	BSK-4	test	11:46	11:48	200	4	0.02	whitefish			45			19			1																														1								
June	06/21/1999	Beach near Bethel*		NA*	NA	NA	80	20		whitefish				14		6																																									
June	06/22/1999	Johnson	BSJ-1	test	10:50	10:52	Not Checked	No Data																							1																												
June	06/22/1999	Johnson	BSJ-2	control	NA	12:06	Not Checked	No Data					1			1																																									
June	06/22/1999	Johnson	BSJ-2	test	14:18	14:20	Not Checked	No Data																							1																												
June	06/23/1999	Kuskokwim	BSK-5	test	13:55	13:58	Not Checked	No Data					2			17						1			2																				1			1											
June	06/23/1999	Kuskokwim	BSK-5	control	NA	13:10	Not Checked	No Data								25						1			4						1																	4											
June	06/23/1999	Kuskokwim	BSK-7	test	12:02	12:04	100	1	0.01	whitefish						2																																									
June	06/23/1999	Kuskokwim	BSK-4	test	10:02	10:04	Not Checked	No Data					74			6																																	1								
June	06/23/1999	Kuskokwim	BSK-4	control	NA	not recorded	Not Checked	No Data			1		176			22			3																														2								
June	06/24/1999	Kuskokwim	BSK-6	control	NA	9:10	Not Checked	No Data					14	1	2	96			3			3			3																		2																
June	06/24/1999	Kuskokwim	BSK-6	test	9:50	9:52	Not Checked	No Data					1			7																																									
July	07/07/1999	Kuskokwim	BSK-6	control	NA	11:05	Not Checked	No Data								71						4			2			1																													
July	07/08/1999	Kuskokwim	BSK-6	control	NA	12:24	Not Checked	No Data								102						2												2																							
July	07/08/1999	Kuskokwim	BSK-8	test	14:10	14:12	Not Checked	No Data								34						1																																			
July	07/08/1999	Kuskokwim	BSK-6	test	13:19	13:22	Not Checked	No Data							2	96						10						3						6																							
July	07/08/1999	Beach near Napakiak*		NA*	NA	NA	80	1		whitefish						1																																									
July	07/09/1999	Kuskokwim	BSK-4	control	NA	9:34	Not Checked	No Data							2	145			1			9																																			
July	07/09/1999	Kuskokwim	BSK-4	test	18:23	18:25	200	2	0.01	whitefish						144									2																																
July	07/09/1999	Kuskokwim	BSK-6	test	15:20	15:22	200	4	0.02	3 whitefish / 1 sucker						61			1			7						2																													
July	07/09/1999	Kuskokwim	BSK-5	control	NA	not recorded	Not Checked	No Data						1		9						28			3									11														1											
July	07/09/1999	Kuskokwim	BSK-5	test	13:05	13:08	200	0	0							8						6			6									22														1											
July	07/09/1999	Kuskokwim	BSK-4	test	10:17	10:19	200	2	0.01	whitefish						64			1			9			2																				2														
July	07/10/1999	Johnson	BSJ-3	control	NA	not recorded	Not Checked	No Data								6																																									
July	07/10/1999	Johnson	BSJ-3	test	11:43	11:45	200	0	0							64																																							7			
July	07/10/1999	Johnson	BSJ-2	control	NA	not recorded	Not Checked	No Data								289																																									
July	07/12/1999	Kuskokwim	BSK-6	test	10:19	10:21	250	3	0.012	whitefish					1	92	1		1			7			12									1														1											
July	07/12/1999	Kuskokwim	BSK-6	test	9:35	9:37	250	0	0					2		92			1			7			4			2																	1														
July	07/12/1999	Kuskokwim	BSK-6	control	NA	not recorded	Not Checked	No Data						1		139			10			51																																			
July	07/12/1999	Kuskokwim	BSK-4	test	11:50	11:52	400	5	0.0125	whitefish						77			2			10			4									1														1											
July	07/12/1999	Kuskokwim	BSK-5	test	14:52	14:53	200	0	0							7						2			7									17			1								1														
July	07/12/1999	Kuskokwim	BSK-5	control	NA	not recorded	Not Checked	No Data								6						10			3									10			1																				
July	07/12/1999	Kuskokwim	BSK-8	test	13:30	13:32	250	0	0							26						12																																			
July	07/13/1999	Johnson	BSJ-3	control	NA	not recorded	Not Checked	No Data						5		217			1												87																								1					
July	07/13/1999	Johnson	BSJ-2	control	not recorded	not recorded	Not Checked	No Data							1	336															6																									1			
July	07/13/1999	Johnson	BSJ-2	control	NA	not recorded	Not Checked	No Data							1	49									1																																
August	08/13/1999	Kuskokwim	BSK-5	control	NA	11:45	Not Checked	No Data								27						51			13																							1											
August	08/13/1999	Kuskokwim	BSK-4	control	NA	9:48	Not Checked	No Data								6			1			27																							1														
August	08/13/1999	Kuskokwim	BSK-4	test	10:29	10:31	300	0	0							7						19																																			
August	08/13/1999	Kuskokwim	Sandbar near Napaskiak*	NA*	NA	NA	80	0																																																	
August	08/13/1999	Kuskokwim	BSK-3	test	13:53	13:55	Not Checked	No Data								3										33	21	54			10			1																							
August	08/14/1999	Johnson	BSJ-3	control	NA	13:16	Not Checked	No Data								5										36	15	346			4			2																							
August	08/16/1999	Kuskokwim	BSK-4	control	NA	7:53	Not Checked	No Data							1	30						34			3																																
August	08/16/1999	Kuskokwim	BSK-6	test	13:15	13:18	150	0	0							13						4			1																																
August	08/16/1999	Kuskokwim	BSK-6	test	14:27	14:30	150	0	0							170						19			7																																
August	08/16/1999	Kuskokwim	BSK-5	test	16:18	16:20	200	0	0							6						5			92																																
August	08/16/1999	Kuskokwim	BSK-4	test	13:00	13:02	150	0	0							2						4			2																																
August	08/16/1999	Kuskokwim	BSK-4	test	11:39	11:41	150	0	0						2									1																																	
August	08/16/1999	Kuskokwim	BSK-5	test	10:09	10:11	200	0	0							7						8			10																																
August	08/16/1999	Kuskokwim	BSK-4	test	8:42	8:44	250	0	0							3						17																																			
August	08/16/1999	Kuskokwim	BSK-5	control	NA	not recorded	Not Checked	No Data														14			14																																1
August	08/16/1999	Kuskokwim	BSK-4	control	NA	not recorded	Not Checked	No Data														3																																			
August	08/16/1999	Kuskokwim	BSK-4	control	NA	13:00	Not Checked	No Data								1									3																																
August	08/16/1999	Kuskokwim	BSK-6	test	14:25	14:30	100	0	0										23			13																																			

Appendix E – Gillnetting Data

Appendix E Gillnetting Data (1998)

														Control													Test													
Event	Date	River	Station	Location	Observer	Boat Operator	Net Type	Tide Stage	River Stage	Secchi Depth	Wind Speed	Wind Direction	Weather	Net in	Net out	Minutes Fished	Chinook Salmon	Chum Salmon	Coho Salmon	Pink Salmon	Sockeye Salmon	Sheefish	Round Whitefish	Humpback Whitefish	Pike	Other	Net in	Net out	Minutes Fished	Hovercraft Passage Time	Chinook Salmon	Chum Salmon	Coho Salmon	Pink Salmon	Sockeye Salmon	Sheefish	Round Whitefish	Humpback Whitefish	Pike	Other
	MAY																																							
1	05/18/1998	Kuskokwim	K2	Kwethluk 2	RW	Antone	Salmon				calm/10-20 KT		OC/rain	12:10	12:40	30	--	--	--	--	--	--	--	--	--	--	12:50	13:22	32	13:05	--	--	--	--	--	--	--	--	--	--
2	05/19/1998	Kuskokwim	K4	Mouth of Johnson	RW	John	Salmon	High			5 KT	downriver	OC	11:05	11:42	39	--	--	--	--	--	--	--	--	--	--	10:12	10:51	39	10:41	--	--	--	--	--	3	--	--	--	1
3	05/19/1998	Kuskokwim	K5	Oskarville	RW	John	Salmon	High			5 KT	downriver	OC/SB/ rain/hail	12:56	13:27	31	--	--	--	--	--	1	--	--	--	--	13:34	14:05	31	13:41	--	--	--	--	--	--	--	--	--	--
4	05/20/1998	Kuskokwim	K2		RW	Antone	Salmon							15:30	16:02	32	--	--	--	--	--		--	--	--	--	16:02	16:34	32	16:08	--	--	--	--	--	--	--	--	--	--
5	05/20/1998	Kuskokwim	K2	Kwethluk	RW	Antone	Salmon				5-10 KT	downriver	OC/SB	13:45	14:17	32	--	--	--	--	--	1	--	--	--	--	15:01	15:31	30	15:05	--	--	--	--	--	--	--	--	--	--
6	05/20/1998	Kuskokwim	K2	Kwethluk	RW	Antone	Salmon				5-10 KT	downriver	OC/SB/ light breeze	11:27	11:57	30	--	--	--	--	--	--	--	--	--	--	12:53	13:23	30	12:57	--	--	--	--	--	--	--	--	--	--
7	05/21/1998	Johnson	J1	Johnson Fork	RW	Antone	Whitefish		High	2 ft	5-10 KT	north	part cloud	12:48	13:24	30	--	--	--	--	--	--	--	--	--	--	11:40	12:10	30	11:45	--	--	--	--	--	--	--	--	--	--
8	05/21/1998	Johnson	J1	Johnson Fork	RW	Antone	Whitefish		High	2 ft	5-10 KT	north	part cloud	13:24	13:54	30	--	--	--	--	--	--	--	--	--	--	12:10	12:40	30	12:16	--	--	--	--	--	--	--	--	--	--
9	05/22/1998	Kuskokwim	K5	Kwethluk	RW	Antone/ Lynn			High	2 ft				9:20	9:53	33	--	--	--	--	--	--	--	--	--	--	9:53	10:26	32	10:07	--	--	--	--	--	--	--	--	--	--
10	05/22/1998	Kuskokwim	K6	Akiachak	RW	Antone/ Lynn	Salmon		High	2 ft			OC	11:20	11:58	38	--	--	--	--	--	--	--	--	--	--	12:33	13:11	38	12:39	--	--	--	--	--	--	--	--	--	--
11	05/23/1998	Johnson	J2	Paingakm ent	RW	Antone	Whitefish	High/ Flooding			5-10 KT	west	OC/cold	12:22	12:54	32	--	--	--	--	--	1	--	--	--	--	13:40	14:12	32	13:55	--	--	--	--	--	--	--	--	--	--
12	05/23/1998	Johnson	J2	Paingakm ent	RW	Antone/ Lynn	Whitefish	Mid/ Flooding		2 ft	10-15 KT	from west	OC/low clouds	11:45	12:17	32	--	--	--	--	--	--	--	--	--	--	11:10	11:42	32	11:27	--	--	--	--	--	1	--	--	--	--
	JULY																																							
13	07/07/1998	Johnson	J4	Konderak	RW		Whitefish		Flood	2 ft	calm		OC	11:08	11:45	47	--	--	--	--	--	2	--	--	--	--	10:21	11:08	47	10:49	--	--	--	--	--	--	--	--	--	--
14	07/07/1998	Johnson	J4	Kongerak	RW		Whitefish	High/ Flood	High/ Flood	2 ft	calm		OC	12:05	12:38	33	--	--	--	--	--	--	--	--	--	--	13:22	13:55	33	13:25	--	--	--	--	--	--	--	--	--	--
15	07/08/1998	Kuskokwim	K3	Kwethluk	RW	John	Salmon				calm		OC	9:22	9:55	33	--	--	--	--	--	--	--	--	--	--	10:00	10:33	33	10:04	--	1	--	--	--	--	--	--	--	--
16	07/08/1998	Kuskokwim	K10	Section 26	RW	John	Salmon		Highest of year		calm		raining	13:00	13:30	30	--	--	--	--	--	--	--	--	--	--	12:30	13:00	30	12:39	--	14	--	--	--	--	--	--	--	--
17	07/09/1998	Johnson	J-2	Paingakm ent	RW	Hans	Whitefish	Med/ High Flood	High	2 ft	calm		raining	14:24	14:54	30	--	--	--	--	--	--	--	--	--	--	15:59	16:29	30	16:13	--	--	--	--	--	--	--	--	--	--
18	07/11/1998	Kuskokwim	Bluff U	Bethel Bluffs	RW, SP, PV	John	Salmon	Flooding	High/ Flood	6 in	5-10 KT		clear	10:40	11:10	30	--	1	--	--	--	--	--	--	--	--	11:25			11:39	--	--	--	--	--	--	--	--	--	--
19	07/11/1998	Kuskokwim	Bluff L	Bethel Bluffs	RW, SP, PV	John	Salmon	Flooding	High/ Flood	6 in	5-10 KT		clear	10:47	11:17	30	--	--	--	--	--	--	--	--	--	--	11:21	11:51	30	11:39	--	--	--	--	--	--	--	--	--	--
	AUGUST																																							
20	08/21/1998	Kuskokwim	Eddy	Bethel Island	RW, SP	John								13:25	14:03	38	--	--	--	--	--	--	--	--	--	--	12:34	13:25	36	13:04	--	--	1	--	--	--	--	--	--	--
21	08/21/1998	Kuskokwim	Bluff L	Bethel Bluff	RW, SP	John	Salmon	Incoming			0-5 KT		OC	15:25	15:59	34	--	--	1	--	--	--	--	--	--	--	14:49	15:23	34	15:09	--	--	--	--	--	--	--	--	--	--
22	08/21/1998	Kuskokwim	Bluff U	Bethel Bluff	RW, SP	John	Whitefish	Incoming			0-5 KT		OC	15:21	15:56	35	--	--	--	--	--	--	--	--	--	--	14:45	15:20	35	15:09	--	--	1	--	--	--	--	--	--	--
23	08/21/1998	Kuskokwim	Bluff U	Bethel Bluff	RW, PV	Hans	Whitefish	Incoming			0-5 KT		OC	15:59	16:48	49	--	--	--	--	--	--	--	--	--	--	16:49	17:38	49	17:05	--	--	--	--	--	--	--	--	--	--
24	08/21/1998	Kuskokwim	Bluff L	Bethel Bluff	RW, PV	Hans	Salmon	Incoming			5-10 KT		OC	16:06	16:50	44	--	--	--	--	--	--	--	--	--	--	16:51	17:35	44	17:06	--	--	--	--	--	--	--	--	--	--
25	08/21/1998	Kuskokwim	Bluff L	Bethel Bluff	SP	JM	Salmon	Outgoing					OC	10:00	10:30	30	--	--	--	--	--	--	--	--	--	--	9:27	9:58	31	9:30	--	--	--	--	--	--	--	--	--	--
26	08/21/1998	Kuskokwim	Island Eddy	Behtel Island	RW, SP	John	Salmon	Incoming			0-5 KT		OC	15:29	16:04	35	--	--	3	--	--	--	--	--	--	--	14:52	15:27	35	15:12	--	--	1	--	--	--	--	--	--	--
27	08/21/1998	Kuskokwim	Island Eddy	Bethel Island	SP	JM	Salmon	Incoming					Part cloud	16:14	16:52	33	--	--	1	--	--	--	--	--	--	--	16:56	17:29	33	17:04	--	--	--	--	--	--	--	--	--	--
28	08/21/1998	Kuskokwim	Bethel	Bethel Island	RW, PV	Hans	Salmon				0-5 KT		OC	9:55	10:25	30	--	--	--	--	--	--	--	--	--	--	9:23	9:53	30	9:35	--	--	--	--	--	--	--	--	--	--
29	08/21/1998	Kuskokwim	Bluff L	Bethel Bluff	RW, SP	John	Salmon							13:20	13:53	33	--	--	--	--	--	--	--	--	--	--	12:44	13:17	33	13:05	--	--	--	--	--	--	--	--	--	--
30	08/20/1998	Kuskokwim	Bluff L	Bethel Bluff	SP	JM	Salmon	Outgoing					OC	10:00	10:30	30	--	--	1	--	--	--	--	--	--	--	9:25	9:55	30	9:30	1	--	--	--	--	--	--	--	--	--
31	08/20/1998	Kuskokwim	Bluff L	Bethel Bluff	SP	JM	Salmon	Incoming	Outgoing				OC	14:40	15:10	30	--	--	1	--	--	--	--	--	--	--	14:05	14:35	30	14:11	--	--	--	--	--	--	--	--	--	--
32	08/20/1998	Kuskokwim	Napakiak 2	Napakiak	RW	Hans	Salmon	Incoming	Low		5-10 KT		OC	14:15	14:45	30	--	--	--	--	--	--	--	2		--	13:37	14:07	30	13:45	--	--	1	--	--	--	--	--	--	--
33	08/20/1998	Kuskokwim	Point	Bethel Island	RW	Hans	Salmon	Incoming			0-5 KT		OC	10:06	10:36	30	--	--	--	--	--	--	--	--	--	--	9:30	10:00	30	9:35	--	--	--	--	--	--	--	--	--	--
34	08/25/1998	Kuskokwim	Point	Bethel Island	RW, PV	Hans	Salmon	High Tide Slack			calm		OC	10:03	10:37	30	--	--	1	--	--	--	--	--	--	--	9:24	9:54	30	9:34	--	--	--	--	--	--	--	--	--	--
35	08/25/1998	Kuskokwim	Point	Bethel Island	PV	PV/Hans	Salmon	Mid-ebb	High for August		calm		OC	14:50	15:25	35	--	--	1	--	--	--	--	--	--	--	14:18	14:48	30	14:21	--	--	--	--	--	--	--	--	--	--
36	08/25/1998	Kuskokwim	Bluff	Bethel Bluff	SP, PV	JM	Salmon	Outgoing			calm		OC	14:47	15:17	30	--	--	--	--	--	--	--	--	--	--	14:17	14:47	30	14:23	--	--	--	--	--	--	--	--	--	--
37	08/25/1998	Kuskokwim	Bluff	Bethel Bluff	SP, PV	JM	Whitefish	Outgoing			calm		OC	14:50	15:20	30	--	--	--	--	--	--	--	--	--	--	14:19	14:49	30	14:23	--	--	--	--	--	--	--	--	--	--
38	08/25/1998	Kuskokwim	Bluff	Bethel Bluff	SP	JM	Salmon	Out			calm		Drizzle	10:02	10:34	32	--	--	--	--	--	--	--	--	--	--	9:27	9:59	32	9:33	--	--	--	--	--	--	--	--	--	--
39	08/25/1998	Kuskokwim	Bluff	Bethel Bluff	SP	JM	Whitefish	Outgoing			calm		Drizzle	9:58	10:30	32	--	--	--	--	--	--	--	--	--	--	9:25	9:57	32	9:33	--	--	1	--	--	--	--	--	--	--

Appendix E - Gillnetting Data (1999)

Month	Date	River	Station	Location	Set Type	Net Length (ft)	Minutes Fished	Test (#caught)	Control (#caught)	Test								Control							
										chinook salmon	chum salmon	coho salmon	pink salmon	sockeye salmon	sheefish	round whitefish	humpback whitefish	chinook salmon	chum salmon	coho salmon	pink salmon	sockeye salmon	sheefish	round whitefish	humpback whitefish
June	06/16/1999	Kuskokwim	DNK-1	Old Airport	drift	60	32	0	0																
June	06/16/1999	Kuskokwim	GSK-1	Bethel Bluffs	set	60	30	0	0																
June	06/18/1999	Kuskokwim	DNK-1	Old Airport	drift	120	30	0	1									1							
June	06/19/1999	Kuskokwim	DNK-6	Standard Oil	drift	60	20	3	1	1	2								1						
June	06/21/1999	Kuskokwim	DNK-3	Oscarville	drift	60	30	5	4	1	1			3				1	1			2			
June	06/21/1999	Kuskokwim	DNK-1	Old Airport	drift	60	30	2	0		2														
June	06/21/1999	Kuskokwim	DNK-6	Standard Oil	drift	60	30	0	0																
June	06/21/1999	Kuskokwim	DNK-3	Oscarville	drift	120	30	17	9	6	10			1				2	4			3			
June	06/21/1999	Kuskokwim	DNK-1	Old Airport	drift	120	30	5	0	2	3														
June	06/22/1999	Kuskokwim	DNK-3	Oscarville	drift	60	30	2	7	1				1				4	1			2			
June	06/22/1999	Kuskokwim	DNK-3	Oscarville	drift	60	30	3	3	1	2							1	2						
June	06/23/1999	Kuskokwim	DNK-3	Oscarville	drift	120	23	9	15	2	4			3				4	4			7			
June	06/23/1999	Kuskokwim	DNK-2	The "Y"	drift	120	22	8	1	2	4			2				1							
June	06/23/1999	Kuskokwim	DNK-4	Kuskokwak Slough	drift	120	25	0	3									2				1			
June	06/23/1999	Kuskokwim	DNK-1	Old Airport	drift	120	25	3	3	1	1			1								3			
June	06/24/1999	Kuskokwim	DNK-6	Standard Oil	drift	120	15	2	6	1				1				1	3			1	1		
June	06/19/1999	Johnson	GNJ-1A	N. end of Lake Nanvarnaq	set	60	35	0	0																
June	06/19/1999	Johnson	GNJ-1B	N. end of Lake Nanvarnaq	set	60	35	0	0																
June	06/19/1999	Johnson	GNJ-1A	N. end of Lake Nanvarnaq	set	60	35	0	0																
June	06/19/1999	Johnson	GNJ-1B	N. end of Lake Nanvarnaq	set	60	35	0	0																
June	06/22/1999	Johnson	GNJ-3A	Upstream of 1st 90° bend	set	60	25	0	0																
June	06/22/1999	Johnson	GNJ-3B	Upstream of 1st 90° bend	set	60	25	0	1															1	
June	06/22/1999	Johnson	GNJ-2A	Eddy above Lake Nanvarnaq	set	60	30	0	0																
June	06/22/1999	Johnson	GNJ-2B	Eddy above Lake Nanvarnaq	set	60	32	0	0																
July	07/08/1999	Kuskokwim	DNK-3	Oscarville	drift	60	27	4	1	2	2											1			
July	07/08/1999	Kuskokwim	DNK-3	Oscarville	drift	60	25	2	1		2								1						
July	07/08/1999	Kuskokwim	DNK-3	Oscarville	drift	120	25	1	2		1											2			
July	07/08/1999	Kuskokwim	DNK-3	Oscarville	drift	120	25	7	9		7								7			2			
July	07/09/1999	Kuskokwim	DNK-2	The "Y"	drift	60	20	1	3					1				1				2			
July	07/09/1999	Kuskokwim	DNK-1	Old Airport	drift	60	20	1	4					1					3			1			
July	07/09/1999	Kuskokwim	DNK-6	Standard Oil	drift	60	15	5	2		5								2						
July	07/09/1999	Kuskokwim	DNK-1	Old Airport	drift	60	20	1	19					1					16			3			
July	07/10/1999	Kuskokwim	DNK-3	Oscarville	drift	60	20	2	0		2														
July	07/12/1999	Kuskokwim	DNK-5	Akiachak	drift	60	15	4	4		2			2				1				3			
July	07/12/1999	Kuskokwim	DNK-3	Oscarville	drift	60	15	3	0	1				2											
July	07/12/1999	Kuskokwim	DNK-3	Oscarville	drift	60	15	2	2		1			1								2			
July	07/12/1999	Kuskokwim	DNK-1	Old Airport	drift	60	15	2	3		2								2			1			
July	07/12/1999	Kuskokwim	DNK-4	Kuskokwak Slough	drift	60	20	0	1													1			
July	07/12/1999	Kuskokwim	DNK-5	Akiachak	drift	120	15	10	4		3			7								4			
July	07/12/1999	Kuskokwim	DNK-1	Old Airport	drift	120	15	16	16		10			6					15			1			
July	07/12/1999	Kuskokwim	DNK-3	Oscarville	drift	120	17	7	3		1			6								3			
July	07/12/1999	Kuskokwim	DNK-3	Oscarville	drift	120	15	6	1					6								1			
July	07/13/1999	Kuskokwim	DNK-3	Oscarville	drift	60	20	1	0		1														
July	07/10/1999	Johnson	GNJ-4A	S. end of Lake Nanvarnaq	set	60	30	0	0																
July	07/10/1999	Johnson	GNJ-4B	S. end of Lake Nanvarnaq	set	60	30	0	0																
July	07/10/1999	Johnson	GNJ-3A	Upstream of 1st 90° bend	set	60	25	1	0							1									
July	07/10/1999	Johnson	GNJ-3B	Upstream of 1st 90° bend	set	60	30	0	0																
July	07/13/1999	Johnson	DNJ-1	Upstream of 1st 90° bend	drift	60	20	2	2						1	1							2		
July	07/13/1999	Johnson	DNJ-2	Upstream of 1st 90° bend	drift	60	16	2	6							1	1							6	
July	07/13/1999	Johnson	GNJ-5	Mouth of stream near DNJ-2	set	60	30	1	0							1									
August	08/13/1999	Kuskokwim	DNK-5	Akiachak	drift	120	15	5	4			5								4					
August	08/13/1999	Kuskokwim	DNK-6	Standard Oil	drift	120	18	0	1												1				
August	08/13/1999	Kuskokwim	DNK-1	Old Airport	drift	120	18	3	0			2		1											
August	08/16/1999	Kuskokwim	DNK-1	Old Airport	drift	120	16	12	4			12								4					
August	08/18/1999	Kuskokwim	DNK-1	Old Airport	drift	60	15	5	2			5								2					
August	08/18/1999	Kuskokwim	DNK-5	Akiachak	drift	60	15	0	2											2					
August	08/18/1999	Kuskokwim	DNK-6	Standard Oil	drift	60	15	0	0																
August	08/18/1999	Kuskokwim	DNK-1	Old Airport	drift	120	20	1	1			1								1					
August	08/18/1999	Kuskokwim	DNK-1	Old Airport	drift	120	20	0	0																
August	08/18/1999	Kuskokwim	DNK-6	Standard Oil	drift	120	15	4	0			4													
August	08/18/1999	Kuskokwim	DNK-1	Old Airport	drift	120	15	6	7			6								7					
August	08/18/1999	Kuskokwim	DNK-5	Akiachak	drift	120	12	1	12			1								12					
August	08/18/1999	Kuskokwim	DNK-1	Old Airport	drift	60	20	0	1											1					
August	08/18/1999	Kuskokwim	DNK-1	Old Airport	drift	60	20	0	0																
August	08/20/1999	Kuskokwim	DNK-1	Old Airport	drift	120	10	16	17			15				1				17					
August	08/14/1999	Johnson	GNJ-3	Upstream of 1st 90° bend	set	60	18	0	0																
August	08/14/1999	Johnson	DNJ-1	Upstream of 1st 90° bend	drift	60	12	5	2						5								2		
August	08/17/1999	Johnson	DNJ-1	Upstream of 1st 90° bend	drift	60	18	3	1						3								1		
August	08/17/1999	Johnson	DNJ-2	Upstream of 1st 90° bend	drift	60	20	0	0																
August	08/17/1999	Johnson	DNJ-1	Upstream of 1st 90° bend	drift	60	15	2	0							2									
August	08/17/1999	Johnson	DNJ-3	1 mile past 1st 90° bend	drift	60	20	0	0																
August	08/21/1999	Johnson	DNJ-1	Upstream of 1st 90° bend	drift	60	20	2	1						1		1						1		
Totals								205	192	21	68	51	0	46	10	7	2	19	62	50	1	46	7	7	0

Appendix F – Waterfowl Counts Conducted by Motorboat (1999)

Appendix F - Waterfowl Counts Conducted by Motorboat (1999)

Kuskokwim River

Month	Date	Transect	Ducks	Geese	Swans
June	06/16/1999	WFTK1	14	0	0
June	06/19/1999	WFTK1	7	0	0
June	06/18/1999	WFTK1	1	0	0
June	06/17/1999	WFTK1	16	0	0
June	06/21/1999	WFTK1	9	0	0
June	06/22/1999	WFTK1	2	0	0
July	07/07/1999	WFTK1	1	0	0
July	07/08/1999	WFTK1	44	0	0
July	07/09/1999	WFTK1	15	0	0
July	07/10/1999	WFTK1	93	0	0
July	07/13/1999	WFTK1	50	0	0
August	08/09/1999	WFTK1	27	0	0
August	08/10/1999	WFTK1	0	0	0
August	08/11/1999	WFTK1	11	0	0
August	08/12/1999	WFTK1	0	0	0
August	08/13/1999	WFTK1	2	0	0
Total			**292**	**0**	**0**
# surveys			**16**	**16**	**16**
Average # observed			**18.3**	**0.0**	**0.0**
Average # observed / km			**2.6**	**0.0**	**0.0**

Transect Characteristics
Length: 7.0 km
Average channel width: 200-400 yds
Percent Beach: 84%
Percent Cut-Bank: 16%

Gweek River

Month	Date	Transect	Ducks	Geese	Swans
June	06/16/1999	WFTG1	2	0	0
June	06/19/1999	WFTG1	2	0	0
June	06/18/1999	WFTG1	0	0	0
June	06/17/1999	WFTG1	3	0	0
June	06/21/1999	WFTG1	1	0	0
June	06/22/1999	WFTG1	0	0	0
July	07/07/1999	WFTG1	0	0	0
July	07/08/1999	WFTG1	2	0	0
July	07/09/1999	WFTG1	6	0	0
July	07/13/1999	WFTG1	17	0	0
August	08/09/1999	WFTG1	1	0	0
August	08/10/1999	WFTG1	13	0	0
August	08/11/1999	WFTG1	7	0	0
August	08/12/1999	WFTG1	0	0	0
August	08/13/1999	WFTG1	15	0	0
Total			**69**	**0**	**0**
# surveys			**15**	**15**	**15**
Average # observed			**4.6**	**0.0**	**0.0**
Average # observed / km			**1.5**	**0.0**	**0.0**

Transect Characteristics
Length: 3.0 km
Average channel width: 100-200 yds
Percent Beach: 88%
Percent Cut-Bank: 12%

Slough off Kuskokwim

Month	Date	Transect	Ducks	Geese	Swans
June	06/16/1999	WFTS1	8	0	0
June	06/19/1999	WFTS1	8	0	0
June	06/18/1999	WFTS1	8	0	0
June	06/17/1999	WFTS1	10	0	0
June	06/21/1999	WFTS1	10	0	0
June	06/22/1999	WFTS1	2	0	0
July	07/07/1999	WFTS1	58	0	0
July	07/08/1999	WFTS1	32	0	0
July	07/09/1999	WFTS1	46	0	0
July	07/13/1999	WFTS1	77	0	0
August	08/09/1999	WFTS1	30	0	0
August	08/10/1999	WFTS1	36	0	0
August	08/11/1999	WFTS1	27	0	0
August	08/12/1999	WFTS1	27	0	0
August	08/13/1999	WFTS1	21	0	0
Total			**400**	**0**	**0**
# surveys			**15**	**15**	**15**
Average # observed			**26.7**	**0.0**	**0.0**
Average # observed / km			**13.3**	**0.0**	**0.0**

Transect Characteristics
Length: 2.0 km
Average channel width: 50-100 yds
Percent Beach: 100%
Percent Cut-Bank: 0%

Johnson River

Month	Date	Transect	Ducks	Geese	Swans
June	06/16/1999	WFTJ1	3	0	0
June	06/19/1999	WFTJ1	27	0	0
June	06/18/1999	WFTJ1	20	0	0
June	06/17/1999	WFTJ1	13	0	0
June	06/21/1999	WFTJ1	18	0	0
June	06/22/1999	WFTJ1	38	0	0
July	07/07/1999	WFTJ1	13	0	0
July	07/08/1999	WFTJ1	42	0	0
July	07/09/1999	WFTJ1	27	0	0
July	07/10/1999	WFTJ1	29	0	0
July	07/13/1999	WFTJ1	25	0	0
August	08/09/1999	WFTJ1	13	0	1
August	08/10/1999	WFTJ1	2	20	0
August	08/11/1999	WFTJ1	24	35	0
August	08/12/1999	WFTJ1	6	39	0
August	08/13/1999	WFTJ1	0	52	0
Total			**300**	**146**	**1**
# surveys			**16**	**16**	**16**
Average # observed			**18.8**	**9.1**	**0.1**
Average # observed / km			**1.3**	**0.6**	**0.0**

Transect Characteristics
Length: 14.7 km
Average channel width: 100-200 yds
Percent Beach: 66%
Percent Cut-Bank: 34%

Pikmiktalik River

Month	Date	Transect	Ducks	Geese	Swans
June	06/16/1999	WFTP1	2	0	0
June	06/19/1999	WFTP1	17	0	0
June	06/18/1999	WFTP1	6	0	0
June	06/17/1999	WFTP1	15	0	0
June	06/21/1999	WFTP1	8	0	0
June	06/22/1999	WFTP1	8	0	0
July	07/07/1999	WFTP1	1	0	0
July	07/08/1999	WFTP1	2	0	1
July	07/09/1999	WFTP1	27	0	0
July	07/10/1999	WFTP1	2	0	0
July	07/13/1999	WFTP1	1	0	0
August	08/09/1999	WFTP1	4	0	0
August	08/10/1999	WFTP1	1	0	0
August	08/11/1999	WFTP1	0	0	0
August	08/12/1999	WFTP1	4	2	0
August	08/13/1999	WFTP1	1	1	0
Total			**99**	**3**	**1**
# surveys			**16**	**16**	**16**
Average # observed			**6.2**	**0.2**	**0.06**
Average # observed / km			**0.8**	**0.0**	**0.01**

Transect Characteristics
Length: 7.5 km
Average channel width: 50-100 yds
Percent Beach: 95%
Percent Cut-Bank: 5%

Appendix G – Scientific Names for Species Mentioned in Report

Appendix G – Scientific Names for Species Mentioned in Report

Common Name	Scientific Name
Fish	
Blackfish (Alaska)	*Dallia pectoralis*
Chinook/King Salmon	*Oncorhynchus tshawytscha*
Chum Salmon	*Oncorhynchus keta*
Coho Salmon	*Oncorhynchus kisutch*
Sockeye Salmon	*Oncorhynchus nerka*
Sheefish	*Stenodus leucicthys*
Longnose Sucker	*Catostomus catostomus*
Humpback Whitefish	*Coregonus pischiar*
Round Whitefish	*Prosopium cylindraceum*
Birds	
Arctic tern	*Sterna paradisaea*
Bald eagle	*Haliaeetus leucocephalus*
Black turnstone	*Arenaria melanocephala*
Canada goose	*Branta canadensis*
Common raven	*Corvus corax*
Gull	*Larus* spp.
Sandhill crane	*Grus canadensis*
Semi-palmated plover	*Charadrius semipalmatus*
Tundra swan	*Cygnus columbianus*

Appendix H – Distribution List for the *Draft Ecological Monitoring Summary Report*

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