AVIAN HABITATS OF THE YUKON DELTA

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The active delta of the Yukon River appears in LANDSAT satellite imagery as represented in Fig. 1. We wish to emphasize the word active in the above sentence, for this discussion does not deal with the older portion of the delta extending southward almost to the Kuskokwim River, but is limited to that portion through which the Yukon River now flows. It is described by Dupre' (1977) as complex, with twelve active distributaries and a number of sloughs draining into Norton Sound, an embayment of Bering Sea. The Yukon River is the 17th largest in the world (Lisitzin 1972), discharging over 1,000,000 cfs of water during its peak flow in spring (Dupre' 1977), and transporting over 88 million metric tons of suspended sediment annually (Lisitzin 1972). This sediment load makes the water opaque in summer especially in the two larger distributaries that carry the major volume of water. These are Kwikluak Pass or South Mouth, and Kawanak Pass or Middle Mouth. The discharge of fresh water materially reduces salinity in Norton Sound.

The numerous sloughs, which form a network of waterways, are partially abandoned river courses which intermittently drain upstream flooding (Dupre' 1977). Except for this intermittent flow which prevents complete abandonment, the major water exchange is tidal. Such a slough, known as Uwik Slough, runs through a study area indicated in Fig. 1 by a small rectangle at the northernmost point of the delta. In Uwik Slough the tide range is about 1.3 meters. Water depth near the mouth is three or more meters but diminishes upstream. In the section eleven to eighteen kilometers upstream from the mouth, depth is about five centimeters at low tide with a barely discernable downstream flow. Above eighteen kilometers to its confluence with a small distributary at about twenty-four kilometers its depth increases, but shoals again to less than thirty-eight centimeters at its head. The flow on flooding tides is upstream, on ebbing tides downstream. Velocities of the flow in this cycle follow a roughly sinusoidal pattern, but as the tide is of the "mixed type" (Sverdrup, Johnson and Fleming 1942) marked inequalities occur. We are describing what might be called "normal conditions" in summer following decline from the river's highest level at peak flow in spring. Storm tides, which usually occur in fall, create flood conditions on the delta that radically alter its hydrology.

In addition to the sloughs long enough to drain upstream flooding there are many smaller sloughs on the outer perimeter of the delta having no connection, except through Norton Sound, to the river. Other than rain runoff and snow melt the entire source of water in these small sloughs is tidal. In Fig. 3, an expansion of the Uwik Slough study area drawn from National Ocean Science aerial photography, these features may be seen. Geologist Dupre' (1977) defines this coast as "prograding." That is, deposition of sediment brought downstream by the Yukon River is building the shore rapidly outward.

The dashed line in Fig. 3 represents an old shoreline about two kilometers inland from the present one shown by a hatched line. It is clearly visible in both satellite imagery and aerial photography, and on the land by an abrupt elevational change of about 15 cm. The recent deposits, lying seaward of the old shoreline, are emergent only on the

lower portions of the tide cycle. Spring tides (Sverdrup, Johnson and Fleming 1942, p 559) flood nearly the whole of the recent deposits, while neap tides flood correspondingly less. The present shoreline approximates the outer limit of emergent vegetation, but this margin is in reality quite indefinite. Seaward of this shoreline lie mudflats across which the sloughs have cut channels as shown in Fig. 3. These are exposed at low tide. Thus the whole of the recent deposits constitute an intertidal zone with the upper portion dominated by a rank growth of Carex Ramenskii. Above the old shoreline the vegetation is drier, and though still dominated by C. Ramenskii, is less rank and more diverse.

We have drawn attention in an earlier report (Jones and Kirchhoff 1977) to the prevalence of flooding on the delta, and these remarks about a flooded and a drier zone do not constitute a different viewpoint. We wish to emphasize the frequency of flooding in a zone that makes it of importance to waterfowl and other birds. Normal high tides, especially spring tides flood the zone below the old shoreline; while storm tides, particularly if they coincide with spring tides, flood that above it as well. One consequence of the regular flooding below the old shoreline is a buildup of ice during the winter. This, except for deep drifts in the outer edge of the willow stands, is the last ice to disappear from the delta in spring.

Satellite imagery and aerial photography reveal that suspended sediment is unevenly distributed in the water off the coast of the Yukon delta. The discharge from the distributaries is so cloudy that no hint of light penetration can be detected in either satellite imagery or aerial photography. From the sloughs, however, much less sediment is discharged and light penetration is sufficient to reveal detail in the substrate, especially in aerial photography. Satellite imagery shows three zones of densely cloudy water off the major distributaries with two bands of relatively clear water between these cloudy zones, close inshore. The two relatively clear zones are represented in Fig. 2. These zones are euphotic and in the zone encompassing the study area there is a stand of Potamogeton filiformis in which a large population of pintails feeds from mid-June to the end of August. The distribution of P. filiformis and pintails coincide with the northernmost zone of relative water clarity shown in Fig. 2. We have no data concerning the second zone, but the similarity in satellite imagery suggests it too supports a stand of P. filiformis and a population of pintails.

A major event of the year on the Yukon River delta is the breakup of the river ice in spring. This event is accompanied annually by flooding of those parts of the delta associated with the large distributaries of the river. We illustrate in Fig. 4 the extent of the flood in 1975 based on satellite imagery dated May 29. We do not suggest that the magnitude of this flood is either greater or less than "normal" for no adequate data for establishing a mean are available. The point of this illustration is that flooding occurs along the distributaries, particularly

the major ones. Such annual flooding must inevitably influence the evolution of nest site selection for ground nesting birds that initiate egg laying before breakup. This includes both pintails and Canada geese, representing the largest waterfowl populations on the delta.

The activities reported in Jones and Kirchhoff 1977 constituted a reconnaissance of the north-central portion of the Yukon delta to determine areas of high waterfowl use. The present report deals with activities in the Uwik Slough study area in which high waterfowl use had been found. Three persons were involved in these activities, two of whom had conducted the reconnaissance a year earlier. These are the authors of this report, and Allen M. Joseph of Hooper Bay, Alaska. Joseph joined the project as a student from Kuskokwim City College in Bethel.

Field work commenced May 2 with the arrival of Jones in the village of Kotlik on the delta. The plan had been to proceed immediately to the Uwik Slough study area, but the melt of river ice was advanced and it was thought unwise to travel over it with the necessary loads. The phenology of the spring migration presented here is therefore based on observations in the Kotlik area with quite different habitat than on the coast.

Kirchhoff arrived in Kotlik June 1 during breakup, which began in that area about 2300 May 31st. At that time the ice broke and moved downriver for about an hour, then stopped. The event was rather dramatic. The river's surface (Apoon Pass, one of the distributaries), long frozen into immobility, abruptly assumed a sharply angular profile. The broken pieces of ice worked against one another tilting into all angles from horizontal to vertical, while the whole mass moved toward the Sound. Then equally abruptly the movement stopped and the grinding sounds ceased. Twenty four hours later the movement resumed and by the morning of June 2nd the river was open to boat travel, though moving ice floes still presented problems. Jones and Kirchhoff departed that date by canoe for the study area. Ice and snow blocked Uwik Slough about 15 kilometers short of the intended destination, where camp was finally established June 5. Joseph arrived June 18. Studies were initiated when camp was established and continued through August 28 for a total of 81 days. Camp was closed the 29th and the personnel departed the delta.

We chose replicate transect sampling methods to document avian usage. Two are illustrated in Fig. 3, one crossing the vegetated upper portion of the intertidal zone and the other the intertidal mud flats. Kirchhoff marked the first of these June 8th while the mudflats still lay under ice. It consisted of thirteen stations 175 meters apart beginning at the ancient shoreline. The transect followed a straight line north northwest to a point just beyond the present shoreline. Observations began June 9th. The procedure was to observe birds in a right triangle bounded by the observer at one station, the next station, and a stake set 100 meters from that station perpendicular to the transect line. The area encompassed in each triangle was .875 hectares or 11.375 for the entire transect.

The second transect, crossing the intertidal mudflats, required construction of a five meter high observation tower completed June 17th. By this time the ice was gone from the mudflats, and stakes marking a 100 meter wide strip extending north from the tower were set in place June 18th. The tower, indicated in Fig. 3 by a star, was constructed at the outer margin of the vegetated portion of the intertidal zone. Observations began June 19th. The transect was marked by stakes to 1500 meters seaward of the tower, but in practice birds were observed beyond the marks to the limit of visibility at about 1600 or 1700 meters. A 20 power telescope was employed for the purpose from the top of the tower.

A third transect (not shown) was laid out June 11th due east from the camp site 1400 meters to the first tidal slough. This was marked by seven stakes spaced at 200 meters.

We have referred to the upper portion of the intertidal zone as vegetated, and the lower portion as mudflats. This is not to imply that the mudflats are devoid of vegetation, for the stand of Potamogeton filiformis, already mentioned, occupies this zone. A slight elevation of the substrate located 1000 to 1300 meters offshore forms a tidal pool on the inshore side in which the Potamogeton grows abundantly. Associated with this vegetation is a community of brackish-water invertebrates, of which the most abundant is Neomysis intermedia. Others include the isopod Saduria entomon, a gammarid amphipod Pontoporeia affinis, and a polychaete Scolecolepides viridus.

Kirchhoff collected 16 trawl samples in this community at low tide August 13 and again August 20. The first station for these samples was 100 meters offshore, with successive stations 100 meters farther out to the 1600 meter mark. The sampler was a long-handled sweep net with an elliptical opening having a long radius 19.5 cm, and a short radius 6.0 cm. The net material was a fabric screen with openings 0.75 mm square. The sampler was drawn through 20 meters of water and substrate, sampling all the water and a strip of mud about 20 cm wide. It furnishes a realistic estimate of invertebrates inhabiting the water column (Neomysis intermedia), but less so for the isopods and amphipods on or in the mud. The samples have been analyzed to furnish density estimates, listed in Table 1. The estimates for Neomysis intermedia are presented in graphic form in Fig. 5.

Kirchhoff again collected samples on the mudflats August 21 at low tide. This time the samples were cores of the mud itself, each circular, covering an area of .023 square meters to a depth of 4 cm. Ten samples were taken at each station beginning 100 meters offshore with successive stations seaward to the 1900 meter mark. These samples have been analyzed to furnish density estimates of the isopods and amphipods. The results are listed in Table 2 and presented graphically in Fig. 6.

We have designated the transect crossing the mud flats as transect A, and the other crossing the vegetated zone between the old and the new shoreline transect B. The numbers of replicate counts total 418 for all birds on these sampling areas over an 80 day period from June 10 through August 28. Transect A was counted 195 times, transect B 233. The data

for pintails have been analyzed and correlated with the stage of the tide over 10 time periods of eight days. The results are presented in Table 3. Parenthetic figures represent the number of replicate samples These same data are presented graphically in Figs. 7 and 8.

Certain trends may be observed in these graphs. (1) numbers of pintails on transect B are highest in early June. This was also true on the third transect (not shown in Fig. 3) extending east from camp. This coincided with the presence of extensive ice cover on the mudflats (transect A), but probably also with low invertebrate density on the mudflats. (2) Pintail numbers on the two transects exhibit an inverse relationship with respect to the rising tide. The numbers decline on transect A with the rising tide, but increase on transect B. (3) Pintail numbers on both transects drop sharply during the period of the molt in early to mid-July. (4) After the molt the numbers on the mudflats reach their highest level. This certainly reflects an accretion of young birds, but probably of invertebrates as well. It perhaps also reflects reduction of inland wetland acreage through evaporation.

August 3rd a flight was made in a light aircraft over the mudflats. The flight extended from Apoon Pass (or North Mouth) to Kwikluak Pass (or Middle Mouth), beginning and ending over the opaque, sediment-laden water of these two distributaries, with the relatively clear water between (see Fig. 2). The latter zone was marked by the appearance of submerged plant growth (Potamogeton filiformis) and numerous pintails. The pintails observed on that flight were estimated to number 41,550.

The transect counts have been expanded to furnish estimates of total pintail numbers on the euphotic mudflats. Counts on transect A for the whole summer season yielded a mean of 83 birds on the 100 meter strip at low tide, or 830 per kilometer. The euphotic zone is 40.25 kilometers in length, hence 830 x 40.25 furnishes an estimate of 33, 407 birds. We consider this estimate does not reflect the true total, for the mean of 83 birds per 100 meters was calculated with all counts including those during the period of the molt when few pintails appeared on the mudflats. The highest average for an eight day period (Aug. 5 - 12) was 151 birds, which expanded to furnish an estimate of 60,777. Expansion of the counts for the period July 28 - Aug. 4 when the aerial estimate of 41,550 birds was secured, yielded an estimate of 49, 910.

Our emphasis on the numbers of birds feeding on the mudflats reflects our observation that this is the largest aggregation of pintails on that part of the delta we studied. It is also the most visible. But despite its size there were many more pintails scattered over the delta. Numerous lakes and marshy areas provided invertebrate populations for food, as did those intertidal mudflats not within the euphotic zone. Saduria entomon is widely distributed on all the mudflats of the delta and several kilometers upstream in the sloughs after the females deposit their young. This had occurred in 1976 by June 25th, and in 1977 we observed it occurring June 17th. In addition to the invertebrates, seeds from three species of Carex (C. Lyngbyaei, C. aquatilis and C. rariflora) were widely available.

Other ducks, particularly shovelers, appeared on the transects but their numbers there were greatly overshadowed by those of the pintails. Most of the other ducks we reported (Jones and Kirchhoff 1977) exhibited a preference for other habitat. Green-winged teal, for example, were present in a flock of several hundred all summer about 14 kilometers upstream from the Uwik Slough mouth, but only appeared on the mudflats in small numbers.

At about 1800 August 19th, the time of higher high tide for that date, the first flocks of pintails were observed in migration flying due east. Thereafter for the remainder of our time on the study area, i.e., through the 28th of August, we observed pintails departing each day at the time of higher high tide. On the 21st, twenty flocks passed our observation point between 2100 and 2200. These averaged about 150 birds per flock. The 22nd at 2100 to 2120 thirteen flocks passed. Several flocks were larger than the previous evening. The last we observed that day at 2225 consisted of four flocks. We estimated 5000 birds to have passed within our view that date. This trend continued, becoming later each evening until we could no longer see, but could hear the migration in progress. From our position at the northernmost point of the delta nearly all of the birds we saw in migration were to the south of us, flying over the land at between 50 and 100 feet elevation, heading due east.

The second largest waterfowl population on the delta comprises two races of Canada geese, lesser Canada geese and cackling Canada geese, the former being much the more abundant. These geese seek nesting sites on the slightly elevated levees of abandoned river courses in the willow zone. The elevations are of about 10 to 15 cm, just enough to permit plant succession leading to a vegetative cover drier than the hydric Carexes. Such habitat is a narrow strip and essentially linear, usually running parallel to willow stands that had developed along the river course. Drift logs and stumps deposited by flood waters produce islands of nesting habitat. Along such low ridges and islands of mesic vegetation the Canada geese, white-fronted geese and pintails nest, widely scattered within the willow zone. A few chose sites between the coast and the willow zone. These three species begin egg laying on the delta about the middle of May.

When the eggs hatch, family groups of geese appear on the sloughs and begin a migration to the coast. In 1977 we saw the first broods of Canada geese June 21st, and for ten days thereafter observed them in a downstream migration. Most travelled about 15 kilometers from just within the edge of the willow zone, but some were observed 26 kilometers upstream. Their destination, with but few exceptions, was the upper intertidal zone lying between the old and the new shorelines in the north section of the Yukon River delta. In 1976 we observed an occasional brood of geese in the lower reaches of sloughs and distributaries east of the eastern end of the ancient shoreline, but even these may eventually have moved to the preferred zone. The concentration of geese in this coastal strip 40 kilometers long during this period of summer is very conspicuous to an observer in an aeroplane, a fact that explains why it is included within the boundaries of the Clarence Rhode National Wildlife Range. The three species of geese nesting on the Yukon delta spend the period during which goslings mature and fledge, and older birds molt

and produce new primaries, in the sloughs of this zone. We suggest that the regular tidal flooding of this area which eliminates mammalian predation has played a major role in the evolution of this behavior. As soon as the birds can fly they disperse over the delta and probably to other areas.

We emphasized study of the two major species of waterfowl on the Yukon River delta not only because of their importance, but because they occupy habitat most vulnerable to contamination by outer continental shelf development. The pintail population on the delta represents about 20 percent of the 287,000 estimated to nest annually in Alaska (U.S. Dept. of Interior 1974). The lesser Canada goose population, about which we do not have firm figures, represents a substantial portion of these birds in Alaska. But other populations of birds also occupy the intertidal zone in varying degrees of abundance. These appeared in both transects, and we developed a record of their numbers on transect B. These data are presented as densities per 100 hectares (247.1 acres), and the frequency of appearance on the transect in Tables 4 and 5. The eleven species listed are the most abundant on the transects after the pintails but do not represent all the birds present. We present finally an annotated list dealing with all the birds we encountered on the delta.

In our 1976 report of activities (Jones and Kirchhoff 1977) we (1) noted the presence of a formidable force of mosquitoes and speculated on its role in the ecology of birds on the delta. We (2) drew attention to the dominance of fresh water in the delta ecosystem, but lacked the means to quantitatively assess the presence of salt. We (3) suggested nothing was known of soil fertility on the delta, and (4) we commented on the inverse relationship in the pH of lake water beginning near the coast and moving upstream.

Such aspects of the delta ecosystem could not be assigned high priority in a bird study spanning a single summer. Never the less, we did seek some answers. We measured salinities in the water at the coast and in the lower reaches of Uwik Slough with a model 33 Yellow Springs Instrument salinity, conductivity and temperature meter. At the coast we found salinities of about four parts per thousand and barely a trace about 12 kilometers upstream at high tide.

Soil fertility tests, conducted with the La Motte STH5 soil test kit revealed in a very general sense the inverse pH relationship to distance from the coast that we observed in the lake water. Available phosphorus and potassium were consistently low. The distribution of nitrates was more variable, but generally fairly adequate. We suggest that the abundant alders may contribute through nitrogen fixing to nitrate fertility. In the willow stands soil fertility measured quite low, suggesting absorption of the scarce nutrients by the trees. With the very low decomposition rates on the delta (Jones and Kirchhoff 1977) this must lead to very slow plant succession.

Published literature concerning mosquitoes in the Arctic deals primarily with their effect on man but little with other animals. Hopla (1964) suggests that passerines, even the naked altricial nestlings, are not attacked by mosquitoes. He describes standing beside a redpoll's nest containing such nestlings. Innumerable mosquitoes were actively attempting to secure blood from the human observer, but made no attempt to do so from the nestlings. He has made this same observation with white-crowned sparrows, yellow warblers, olive-backed thrushes, rusty blackbirds and flickers. He does not suggest how this is achieved.

Corbet and Downe (1966) discuss the vulnerability of loons and ducks to the attacks of mosquitoes. The mosquitoes achieved little success with the loon. Though many of the insects actively probed around the eyes and anal region of an incubating female, only one achieved engorgement. In the case of an incubating common eider they were successful in the area around the birds eyes. The tables were turned, however, shortly after the ducklings hatched, for they quickly learned to catch and eat the pests.

We reared three Canada goose goslings in 1977 and observed that a mosquito approached them at its peril. The birds fed on mosquitoes at any time they came within range, usually catching them in flight. This was also true of other insects, but the abundance of mosquitoes overshadowed all others. We further observed that all birds which allowed us close enough to watch their activities were also feeding on mosquitoes. This included the abundant passerines (savannah sparrow and Lapland longspur) and the shorebirds.

The mosquitoes are most abundant in the willow zone, where they reach (from our viewpoint) intolerable levels. On days when we experienced northerly breezes, i.e., reaching us across Norton Sound, we were free of mosquitoes. Southerly breezes, i.e., from the willow zone, accompanied periods of troublesome levels of the pests, though never comparable to what we experienced in the willows. This suggests that the early life stages are largely restricted to the willow zone, and that the adult females are carried by air currents. Microtine rodents are restricted to the willow zone where they are probably the major blood source for mosquitoes. Snow conditions in winter probably regulate distribution of the rodents. In the willow zone we found sub-nivean temperatures about 30°F., while beyond the willows they were at ambient air temperatures, often too cold for the rodents to survive.

CONCLUSIONS

The avian habitat we have described is unusual, and perhaps unique. Of greatest interest is the intertidal zone in the north central Yukon River Delta where two major populations of waterfowl are present throughout the summer. The tidal range is about 1.3 meters in height, and the intertidal zone is nearly four kilometers wide. About half, which we have designated the upper-intertidal is densely vegetated with Carex Ramenskii. In the lower half is a tide pool in which grow extensive

stands of Potamogeton filiformis. In these stands there is a dense invertebrate community in which large numbers of pintails and shorebirds are observed to feed. Collecting pintails for food analysis proved difficult in the circumstances, however limited success confirmed that the ducks were feeding on the invertebrates. This is a major gap in our knowledge, but even greater is our ignorance of what the invertebrates were eating. The most abundant invertebrate, Neomysis intermedia, is a filter feeder; the isopod, Saduria entomon, is a detritus feeder and scavenger; and the feeding habits of the amphipod Pontoporeia affinis are totally unknown. At low tide these invertebrates become concentrated in shallow water where the ducks and shorebirds feed.

The intertidal zone provides about 150 square kilometers free of mammalian predation, and to this area the broods of geese move after hatching. There they remain until they can fly. The adult and non-breeding geese molt in this area, as do most of the pintails. Few birds nest in this zone because it is too wet, but it becomes the major feeding area for very large numbers once nesting is complete.

An oil spill, a likely consequence of OCS development in or near Norton Sound, would place all this at risk. Such a spill moving onshore in the north central Yukon River delta could freely enter the intertidal zone. We cannot predict in the state of our present knowledge what effect this would have on the invertebrate community, but the effect on birds is all too well known. Immersion in oil is a lethal experience for birds.

Annotated bird list

Arctic loon. The commonest loon on the delta where it breeds successfully. It is found in the larger lakes and in the sloughs. We observed 1.22 per sample count on transect C, not shown but extending due east from our campsite. Observed three times very far offshore, twice observed flying in from offshore with fish in its bill. Not seen in spring 1977 in the Kotlik area, but present in the Uwik Slough study area June 6th.

Red-throated loon. Breeds successfully on the delta, but much less commonly than the arctic. One observed incubating one egg in an island in a lake near our campsite, later abandoned. An adult with two young observed later in study area. Appeared at Kotlik May 14, 1977.

Whistling swan. Fairly common, breeding successfully. Observed a flock of about 100 in the study area west of Uwik Slough during the first week of June 1977. Regularly observed on the transects. Seventeen seen loafing on mudflats June 28. Several family groups observed from an aeroplane August 3rd. Nest near our campsite hatched five cygnets June 30, 1977. Observed in Kotlik area May 5.

Canada goose. Two races, cackling B. c. minima and lesser B. c. parvipes Canada goose, are present on the delta, the latter race very abundant. Both nest in the willow and transition zones, and move their broods to the coast soon after hatching. Most appear to move about 15 kilometers, but others have been observed as much as 26 kilometers inland. The first broods appeared June 21, 1977. Once on the coast they move about in the tidal Carex Ramenskii leaving myriad trails. A flock estimated at more than 700 flew up at the approach of an observer June 26 in the study area east of our campsite. The adults molt in the larger sloughs at the coast. Groups of 6 to 10 adults with up to 35 young were commonly seen far offshore at low tide. After completion of the moult and fledging of the young, the concentration at the coast disperses. By this time crowberries Empetrum nigrum have ripened and the flocks range widely to utilize them. While at the coast they feed on Carex Ramenskii and particularly Carex subspathacea, but appear to utilize most available plants. The three geese we raised from goslings (two cackling and one lesser) exhibited a preference for C. subspathacea and Triglochin palustris; but sought rhizomes of C. Ramenskii, stripped seeds from Deschampsia caespitosa, fed occasionally on the coarse leaves of Elymus arenarius mollis, and produced seeds of C. Ramenskii and C. aquatilis in their droppings after having travelled with other geese. Canada geese were first observed in the Kotlik area May 7th.

Black brant. Seen early in summer 1977 in small flocks at and near the coast in the Uwik Slough study area. One brood of four observed on Uwik Slough in summer 1976. Did not appear in the Kotlik area.

Emperor goose. Common. Tend to breed nearer the coast than other geese. Common on transect line soon after snow melted in June, disappeared in July and then reappeared with family groups. Several nests on small islands in lakes on the study area. Hatching occurred about 1 to 2 weeks later than Canada geese in 1977. Did not appear in the Kotlik area spring 1977.

White-fronted goose. Least abundant of the three geese nesting on the delta. Like the Canada goose nests in the willow zone and moves to the coast at hatching. Fair numbers appeared on the coast in the first two weeks of August 1977. Observed in Kotlik May 6.

Snow goose. Uncommon. Small groups observed in flight on several occasions in early June, once in mid-August 1977. Observed on tide flats June 12. Did not appear in the Kotlik area.

Mallard. Seen occasionally throughout summer, though never more than a few. Probably breeds on the delta in low numbers. Observed at Kotlik May 7th.

Pintail. The most abundant waterfowl species on the delta. Most numerous in the coastal areas where they congregate in flocks near small lakes and meltwater puddles until ice disappears from the mudflats. Largest known concentration on the delta coincides with larger zone of comparatively clear water indicated in Fig.2. Probably forage on Carex seeds prior to ice breakup on the mudflats. In 1977 this event coincided with release of juveniles of Saduria entomon, and with a period of spring tides. Aerial surveys show the great majority of pintails feeding on tide flats exposed at low tide in an area of abundant invertebrates. First molting pintail observed June 23, peak of molt in second week in July. Molting birds congregate in medium sized tidal sloughs. They appear to be mobile with large numbers present one day and absent the next in any given slough. First molting birds regained flight July 16 and returned in even larger numbers to the coast. Invertebrate populations very high in the areas where the pintails feed. On high flood tides the ducks move into the high C. Ramenskii along the coast or fly inland to sloughs and lakes. Large numbers, i.e., more than 500, flushed from C. Ramenskii along transect route in mid-August following high tide. C. Ramenskii seeds frequently found in fecal material suggesting ducks are feeding on seed heads when invertebrates are unavailable due to high tide. Eastward migration started August 19, 1977 when the higher high tide was reached in the evening, and continued at the same tide stage each day thereafter. Migration was still in progress August 28th. Pintails observed May 2 in a puddle alongside the Alakanuk airport, and May 5 in Kotlik.

Green-winged teal. Common and abundant in the willow zone, but uncommon on the coast. Appeared in the Kotlik area May 12.

American wigeon. Breeds on the delta, but not in large numbers. Feeds with the pintails on the mudflats, but never in the Carex stands. Arrived in the Kotlik area May 29.

Shoveler. Second most abundant duck on the delta, though far behind the pintails. Breeds successfully, but later than the pintails. Common on the coast in late July and August. Appeared in the Kotlik area May 29.

Canvasback. A few, probably displaced stragglers from drought conditions in the prairie states and provinces, appeared on the study area. One egg was deposited in an emperor goose nest. It was incubated until pipped, then abandoned. Canvasback were not observed in the Kotlik area.

Greater scaup. Observed regularly in small numbers in sloughs and small lakes, occasionally on the tide flats. None observed in breeding activities. Arrived in the Kotlik area May 29.

Oldsquaw. Rare. One pair observed in Uwik Slough and one female in a lake nearby. Not observed at Kotlik.

Spectacled eider. Seen commonly in the study area where it breeds successfully. One adult female with five young seen almost daily on the transect in the latter half of summer. Not observed in the Kotlik area.

Steller's eider. Five small eiders circled our observer on the transect on one occasion. Noted the small size and short necks. These are thought to have been immature Steller's eiders.

Surf scoter. We reported one small flock in one of the large passes in summer 1976. Drury and Guzman reported several flocks August 8, 1976 numbering 200 to 350 in the shallow, muddy water just north of the mouth of Apoon Pass, Yukon River, within ten miles of shore.

Common merganser. One female observed feeding in a lake on the study area June 19.

Goshawk. Uncommon. Observed only in the willow zone which is the area occupied by microtine rodents.

Rough-legged hawk. Common in the willow zone. The only one observed near the coast alighted on one of our tents in mid-August.

Willow ptarmigan. Restricted to the willow zone. Abundant south of Kotlik.

Lesser sandhill crane. Common throughout the summer. Aerial survey revealed many more on the wet coastal portions of the delta than farther inland. Regularly observed feeding in the upper intertidal zone north of the old shoreline. Most abundant in early June. A possible food source in this area is an abundant gastropod of the genus Lymneae. One nest with two eggs 20 meters from transect line halfway to the outer shoreline discovered June 13, later destroyed by avian predator. Noted a pair of cranes June 21 with two chicks 11.5 kilometers up Uwik Slough. In same area on same date another nest with one egg observed. This nest was sited

on a tree stump deposited by flood waters. An adult crane with one chick was observed on the tidal mudflats July 9. August 1 flocks of high flying cranes were observed. Cranes were observed in the Kotlik area May 5.

Semi-palmated plover. Uncommon. One observed at Kotlik May 14. Later seen several times foraging on tidal mudflats.

Black-bellied plover. Appeared on transect B in small numbers in July and August. Not observed in Kotlik.

Ruddy turnstone. One observed in Kotlik May 15th and again 18th.

Black turnstone. Observed on transect B in June and July. Breeds successfully on the delta. Numerous juveniles were attracted to our campsite in late summer, and became quite tame. Observed May 20 in Kotlik.

Killdeer. One observed near the observation tower June 18.

Common snipe. Common and abundant in the willows. Seen occasionally on transect B late in summer. May be more common than our observations indicate because they hide well and are reluctant to flush from the Carex. Appeared in the Kotlik area May 11.

Whimbrel. Arrived on the delta in large numbers at the end of June. Fed in large flocks with bar-tailed godwits and Hudsonian godwits near the coast. A few stayed on the delta through mid-August, but most were gone by July 15.

Pectoral sandpiper. We have treated these two species as one because
Sharp-tailed sandpiper of the difficulty of distinguishing them. Appeared on the flooded Carex in August. Observed in Kotlik May 25.

Dunlin. One of the most common and abundant shorebirds on the delta. Breeds abundantly above the ancient shoreline. Feeds in mixed flocks of phalaropes and western sandpipers near the coast. Common and abundant on the tidal mudflats. Appeared at Kotlik May 19.

Long-billed dowitcher. First seen July 1st feeding on the tidal mudflats. They with Hudsonian godwits were nearly always probing deeply in the mud. They were also observed feeding in the dried lake bottoms in mid to late August. Abundant with many juveniles in August.

Semi-palmated sandpiper. Very common successful breeder on the delta. Feeds on exposed sloughbanks and on tidal mudflats. Arrived in Kotlik May 14.

Western sandpiper First positive identification June 20, though may have been confused earlier with semi-palmated sandpipers. Though juveniles appeared on the delta we are not sure they nested there.

Greater yellowlegs. One individual observed feeding in Carex at the coast in early August.

Lesser yellowlegs. Approximately 10 individuals were observed feeding on the tidal mudflats in early to mid August.

Solitary sandpiper. One individual caught in a snap trap set on the mudflats.

Bar-tailed godwit. Breeds in the willow zone. Regularly seen feeding in the upper intertidal zone, but noticeably absent in mid-July. Observed in Kotlik May 12.

Hudsonian godwit. First seen foraging with bar-tailed godwits during the first week of July. Very abundant at times on the tide flats in flocks of 200 or more. Large migration through the area in mid-July. Probes deeply in the mud. More abundant than the bar-tailed godwit. Roost in flocks on the levees near the coast during high tide. This is characteristic of most shorebirds on the delta.

Red phalarope. Common and abundant at the coast, never seen elsewhere. One nest near camp hatched June 28th or 29th. Groups of 60 or more observed flying in close formation flocks, swooping high in the air and then returning to alight for a moment before flying again, June 10. Less than 10 birds seen July and August.

Northern phalarope. One of the most abundant birds on the delta. Nest widely on the delta near water. After young fledged, rafts of these birds, mostly in winter plumage, were observed swimming a mile or more offshore. They were among the first birds to leave the delta (third week in August). They arrived at Kotlik May 12.

Wilson's phalarope. Not previously recorded in Alaska according to Gabrielson and Lincoln. One female in breeding plumage observed June 19th foraging on the upper intertidal zone. Drought conditions on the prairies may have displaced this bird.

Parasitic jaeger. Common near the coast, but rare in the willows. One pair nested near our camp site, laying and hatching one egg. The egg pipped June 26th and the chick emerged 29th. Pellets collected on ice June 9 contained small mammal bones and teeth. Later observed preying heavily on shorebird eggs and young. Observed at Kotlik May 30.

Long-tailed jaeger. Common in the willows, less so near the coast. Observed at Kotlik May 12.

Pomarine jaeger. One individual observed July 4th, flying along the coast.

Glaucous gull. Difficult to distinguish from glaucous-winged gull at at a distance. Large gray backed gulls commonly waded in shallow water far out on the tidal flats. Several adults and one second year immature were identified over the course of the summer. The first glaucous gull appeared at Kotlik May 12.

Glaucous-winged gull. Regularly observed overhead or on the tidal flats. Nest found near the coast in 1976. This gull appeared at Kotlik May 7.

Herring gull. One seen on the tidal flats June 28.

Mew gull. Fairly common. Breeds successfully in the willow zone. Common on the tidal flats and sloughs with young in late July and early August. Arrived at Kotlik May 7.

Sabine's gull. Common near the coast, uncommon in the willows. Often observed feeding in flocks of 10 to 20 birds on the upper intertidal zone in early summer. Not seen during August. Observed in Kotlik June 1.

Arctic tern. Common throughout the delta. Breeds successfully along the coast and in the willows. Frequently seen feeding along the transect line on sticklebacks stranded in the Carex stands by the receding tide. Occasionally observed roosting on the tidal flats, but more commonly on logs or slough levees. Observed in Kotlik May 16.

Aleutian tern. Recorded in 1976, but none observed in 1977.

Great horned owl. Twice observed in one location deep within the willow zone June 13 and July 22.

Hawk owl. Observed fairly commonly in the willow zone feeding on microtine rodents.

Tree swallow. Most abundant in Kotlik where nest boxes have been provided, but scattered in the willow zone. These birds visited our camp site several times during 1977. Arrived in Kotlik May 10th.

Northern raven. A permanent resident of the delta. Most common near the villages, especially in winter, but wide ranging. Fairly regularly observed or heard in the coastal zone, perhaps attracted by the nests and young of shorebirds. One pair nested near Uwik Slough approximately 20 kilometers upstream from the mouth. Four young flew from this nest July 5th.

Black-capped chickadee. Observed near Kotlik in January 1977. Like the redpolls, also observed in January, the chickadees were probably feeding on alder seeds.

American robin. Arrived in Kotlik May 13. One nest observed in a small building in 1976.

Varied thrush. Fairly common in the willow zone, but not observed near the coast.

Gray-cheeked thrush. Observed only in the Kotlik area where it arrived May 22.

Yellow wagtail. Uncommon. Observed only in the willows.

Water pipit. One observed near the coast in 1976. On August 20, 1977 a flock of 50 appeared on transect C and others appeared in camp.

Northern shrike. Possibly a permanent resident but not abundant. Observed both years, but only in the willows.

Yellow warbler. Conspicuously abundant in the willows. Arrived in Kotlik June 1.

Rusty blackbird. Migration observed in the Kotlik area May 10. Numerous specimens present at that time, but afterwards seen occasionally in the willow zone.

Common redpoll. Common permanent resident in the willow zone of the delta. Occasionally observed near the coast.

Savannah sparrow. Common in grassy areas, especially in Elymus along slough banks. Abundant around our 1977 camp site where one male proclaimed territorial dominance from the many perching sites provided by our tent stakes and weather instruments. Never again will the occupants of that camp be in doubt regarding the call of the savannah sparrow. Arrived in Kotlik May 19th.

Tree sparrow. Arrived in Kotlik May 21st in modest abundance. Observed only once, June 22, at the coast.

White-crowned sparrow. First heard singing May 12th near Kotlik. Uncommon in the willow zone, one observed near our camp July 3rd.

Fox sparrow. Fairly common in the willow zone. Not observed near the coast. Arrived in Kotlik May 21st.

Lapland longspur. We reported stragglers in 1976 in an area 20 airline kilometers east south east of the Uwik Slough study area, in the edge of the willow zone. In 1977 this species was an abundant successful nester in the Uwik Slough area. Late in the summer there was a dramatic increase in numbers of both juveniles and adults on transect B. They appeared to be feeding on the abundant seeds of Carex Ramenskii.

	6/10-17	6/18-25	6/26-7/3	7/4-11	7/12-19	7/20-27	7/28-8/4	8/5-12	8/13-20	8/21-28
Red phalarope Density/ 100 ha.	1521	47	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Frequency	92%	18%	12%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Northern phalarope Density/ 100 ha.	615	1236	759	1681	1578	1352	1446	711	438	10
Frequency	85%	100%	100%	96%	100%	100%	96%	96%	50%	9%
Arctic tern Density/ 100 ha.	167	218	151	91	71	95	60	50	23	0.0
Frequency	85%	68%	60%	38%	48%	42%	30%	13%	13%	0.0%
Savannah sparrow Density/ 100 ha.	18	36	59	24	0.0	33	10	35	33	85
Frequency	15%	18%	36%	17%	0.0%	13%	9%	26%	21%	35%
Lapland longspur Density/ 100 ha.	88	218	37	10	6	114	596	1396	4124	1933
Frequency	31%	73%	20%	8%	5%	54%	70%	100%	100%	100%

Table 5. Density of five bird species per 100 hectares, and frequency of their appearance on transect B in eight day time periods, June 10 - August 28.

	6/10-17	6/18-25	6/26-7/3	7/4-11	7/12-19	7/20-27	7/28-8/4	8/5-12	8/13-20	8/21-28
Whimb rel Density/ 100 ha.	0.0	0.0	183	314	44	10	0.0	0.0	0.0	0.0
Frequency	0.0 %	0.0 %	12%	50%	24%	8%	0.0 %	0.0%	0.0%	0.0%
Dunlin Density/ 100 ha.	466	1319	155	143	65	62	5	114	271	129
Frequency	100%	91%	64%	46%	43%	42%	4%	35%	33%	43%
Long-billed dowitcher Density/ 100 ha.	0.0	0.0	9	124	136	200	10	154	1176	303
Frequency	0.0%	0.0%	4%	25%	38%	75%	9%	61%	96%	65%
Semi-palmated sandpiper Density/ 100 ha.	150	556	46	33	60	257	0.0	90	14	70
Frequency	54%	68%	24%	21%	24%	63%	0.0%	48%	8%	13%
Bar-tailed godwit Density/ 100 ha.	97	26	279	76	0.0	0.0	15	75	52	0.0
Frequency	46%	14%	40%	21%	0.0%	0.0%	9%	39%	13%	0.0%
Hudsonian godwit Density/ 100 ha.	35	0.0	46	243	201	0.0	0.0	5	0.0	0.0
Frequency	8%	0.0%	12%	29%	38%	0.0%	0.0%	4%	0.0%	0.0%

Table 4. Density of six bird species per 100 hectares, and frequency of their appearance on transect B in eight day time periods, June 10 - August 28.

Time period	Transect	Tide Level (Number of samples) <12"	12-24"	>24"
6/10-6/17	A	0 (0)	0 (0)	0 (0)
	B	18 (5)	24 (3)	67 (5)
6/18-6/25	A	78 (5)	16 (4)	20 (4)
	B	4 (8)	25 (6)	38 (8)
6/26-7/03	A	35 (13)	22 (3)	0 (4)
	B	4 (17)	4 (4)	13 (4)
7/04-7/11	A	11 (13)	7 (3)	1 (8)
	B	1 (13)	0 (3)	4 (8)
7/12-7/19	A	5 (6)	3 (6)	0 (8)
	B	0 (7)	1 (6)	4 (8)
7/20-7/27	A	34 (12)	14 (10)	0 (2)
	B	1 (12)	21 (10)	16 (2)
7/28-8/04	A	124 (9)	63 (6)	27 (8)
	B	4 (9)	9 (6)	56 (8)
8/05-8/12	A	151 (13)	130 (9)	0 (1)
	B	8 (13)	9 (9)	5 (1)
8/13-8/20	A	140 (11)	114 (7)	8 (6)
	B	15 (11)	1 (7)	84 (6)
8/21-8/28	A	139 (14)	75 (9)	14 (1)
	B	3 (14)	10 (9)	5 (1)

Table 3. Average numbers of pintails observed at three stages of the tide on two transects of the Uwik Slough study area. Parenthetic figures indicate numbers of replicate counts.

Distance offshore in meters	Isopods per square meter	Amphipods per square meter
100	13.04	0.00
200	8.70	0.00
300	17.39	0.00
500	78.26	26.09
700	60.87	43.48
900	104.35	91.30
1000	69.51	78.26
1100	13.04	160.70
1200	17.39	113.04
1250	8.70	108.70
1300	30.43	126.09
1350	17.40	82.61
1400	13.04	26.09
1450	4.35	17.40
1500	17.39	26.09
1600	17.39	100.00
1700	8.70	65.22
1800	0.00	13.04
1900	4.35	8.70

Table 2. Invertebrate densities per square meter on the Uwik Slough mudflats, Aug. 21, 1977.

Distance offshore in meters	Mysids		Isopods		Amphipods	
	Aug 13	Aug 20	Aug 13	Aug 20	Aug 13	Aug 20
100	51.59	2.98	3.50	0.00	0.00	0.00
200	38.02	7.06	3.00	1.50	0.00	0.50
300	37.73	45.23	3.75	9.50	0.50	1.50
400	37.79	48.82	22.25	17.50	1.25	1.25
500	30.11	77.91	19.50	12.50	0.50	0.00
600	25.08	87.00	21.50	24.00	0.00	0.25
700	32.91	69.08	35.25	22.50	0.00	0.50
800	64.28	109.73	16.75	14.50	0.00	0.75
900	97.52	106.92	42.75	11.25	0.75	0.50
1000	78.37	187.38	3.00	1.00	1.00	0.25
1100	152.82	132.02	1.75	0.50	0.75	0.00
1200	171.46	172.15	3.00	0.00	0.00	0.00
1300	121.55	103.11	0.00	0.25	0.00	0.75
1400	141.14	158.29	0.00	0.25	0.00	0.00
1500	61.49	5.83	0.25	0.75	2.00	0.25
1600	39.06	11.46	0.00	1.00	0.00	0.25

Table 1. Invertebrate densities per cubic meter in the tide pool at low tide on the Uwik Slough study area, based on trawl samples collected in 1977.

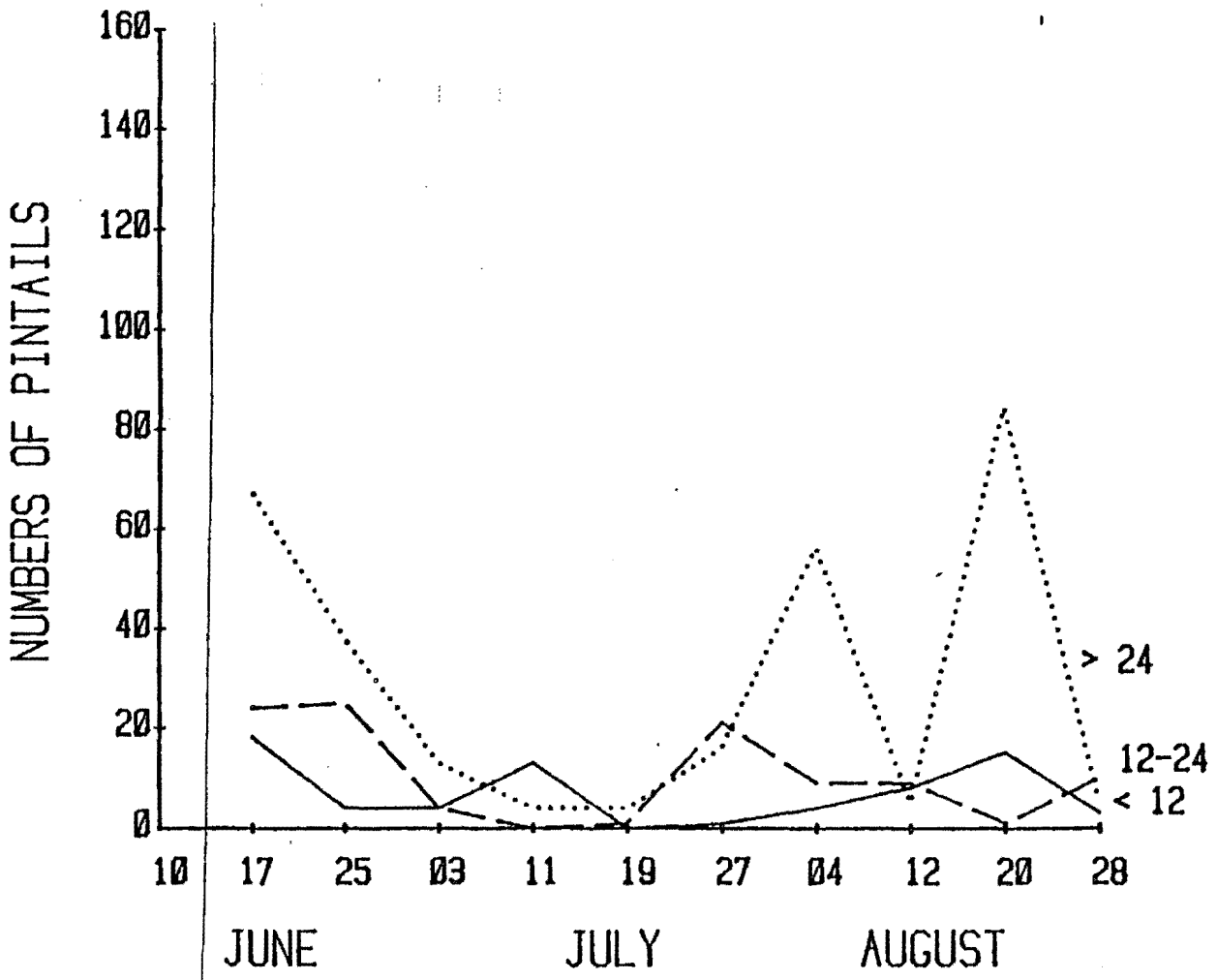


Fig. 8 Average numbers of pintails observed at three stages of the tide on transect B. Tide levels are less than 12 inches, between 12 and 24 inches, and more than 24 inches.

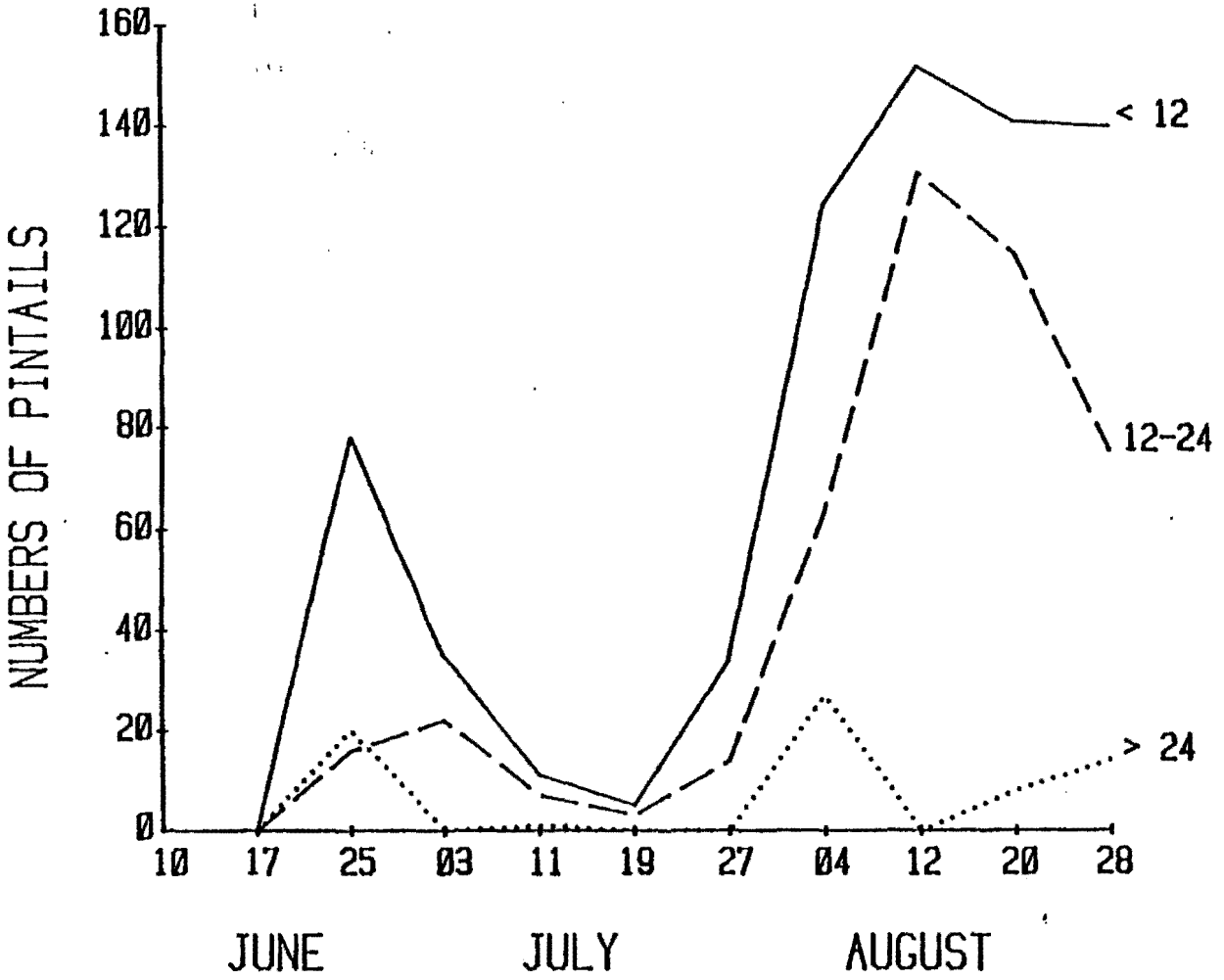


Fig. 7 Average numbers of pintails observed at three stages of the tide on transect A. Tide levels are less than 12 inches, between 12 and 24 inches, and more than 24 inches.

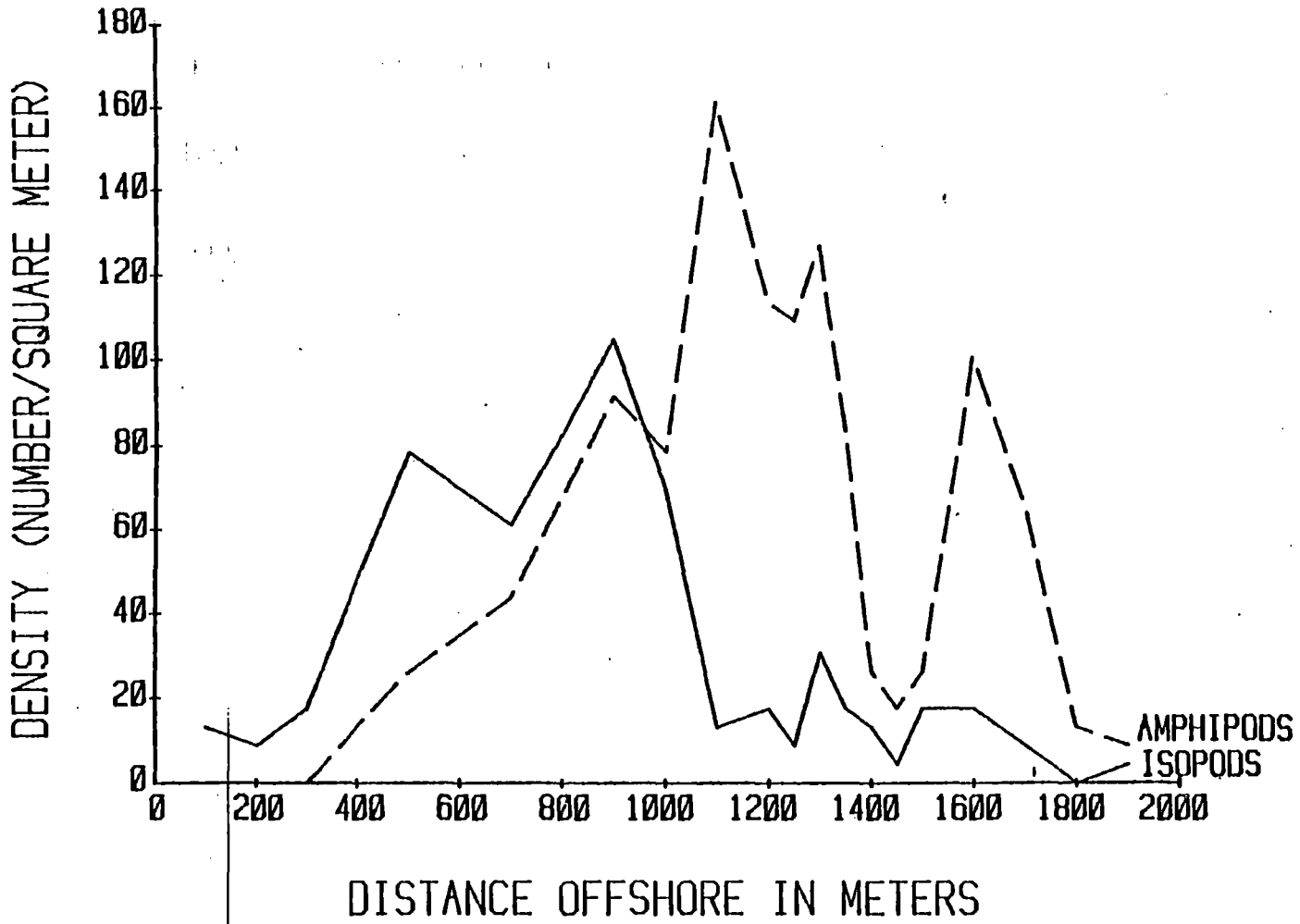


Fig. 6 Densities of amphipods (*Pontoporeia affinis*) and isopods (*Saduria entomon*) on the Uwik Slough mudflats, Aug. 21, 1977.

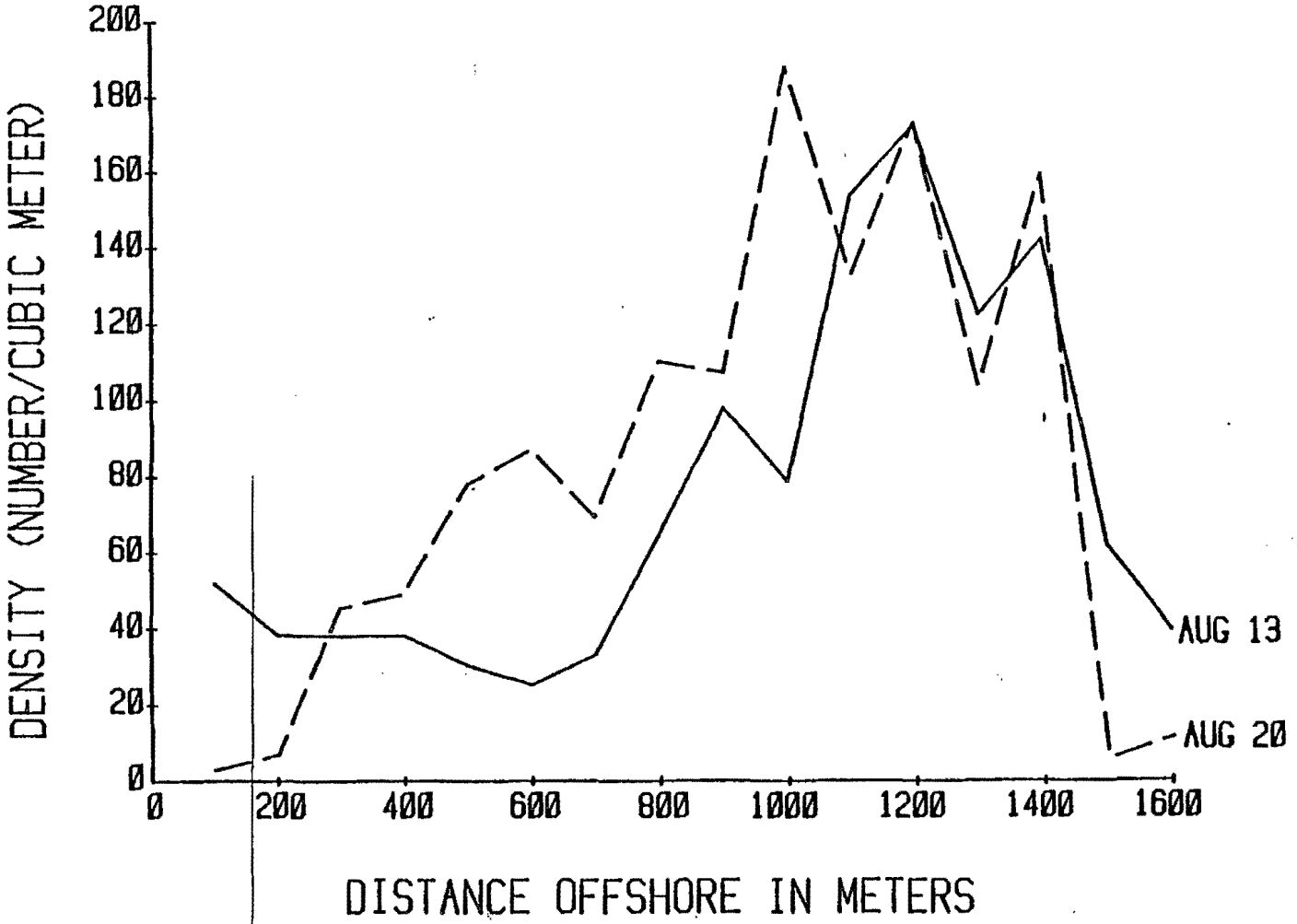
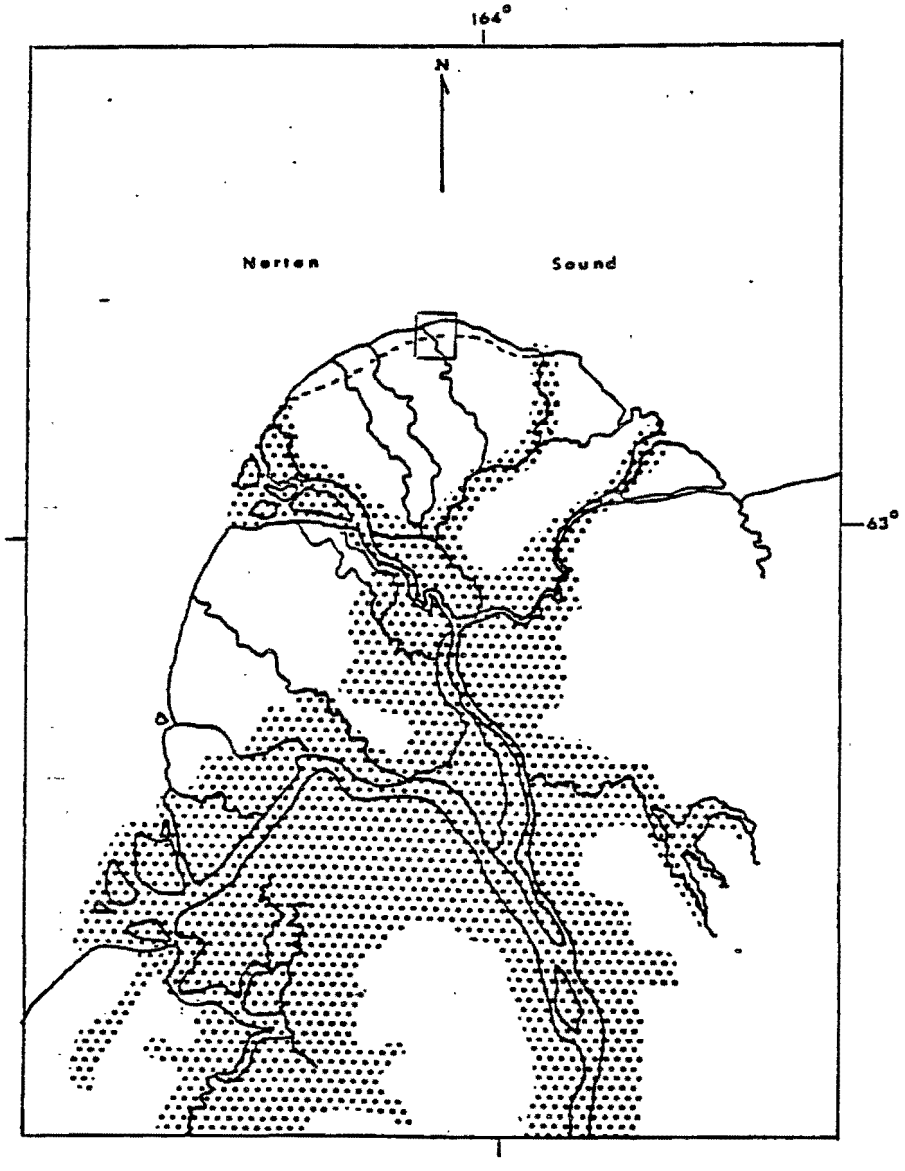


Fig. 5 Densities of *Neomysis intermedia* in the Uwik Slough tide pool. From samples collected in 1977.

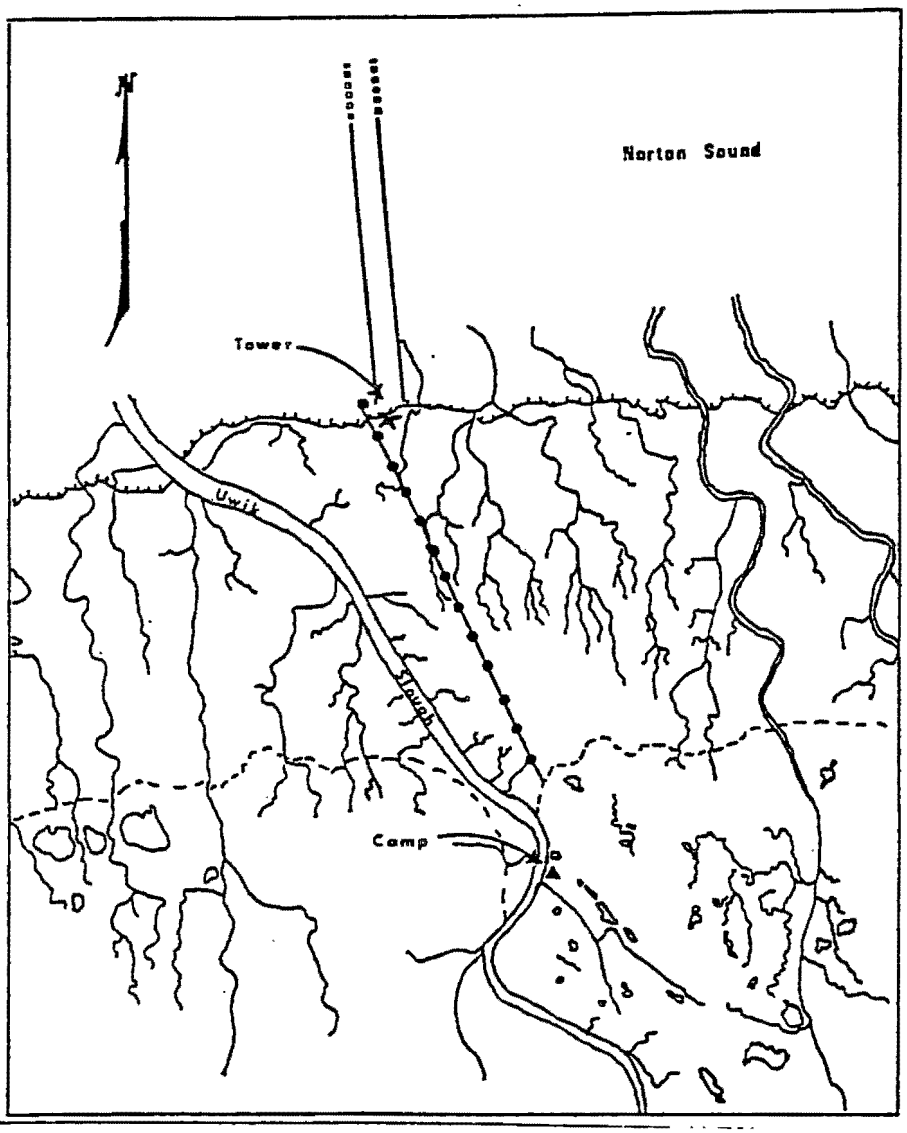


The Yukon River Delta

Under flood May 29, 1975

From Satellite Imagery

Fig. 4

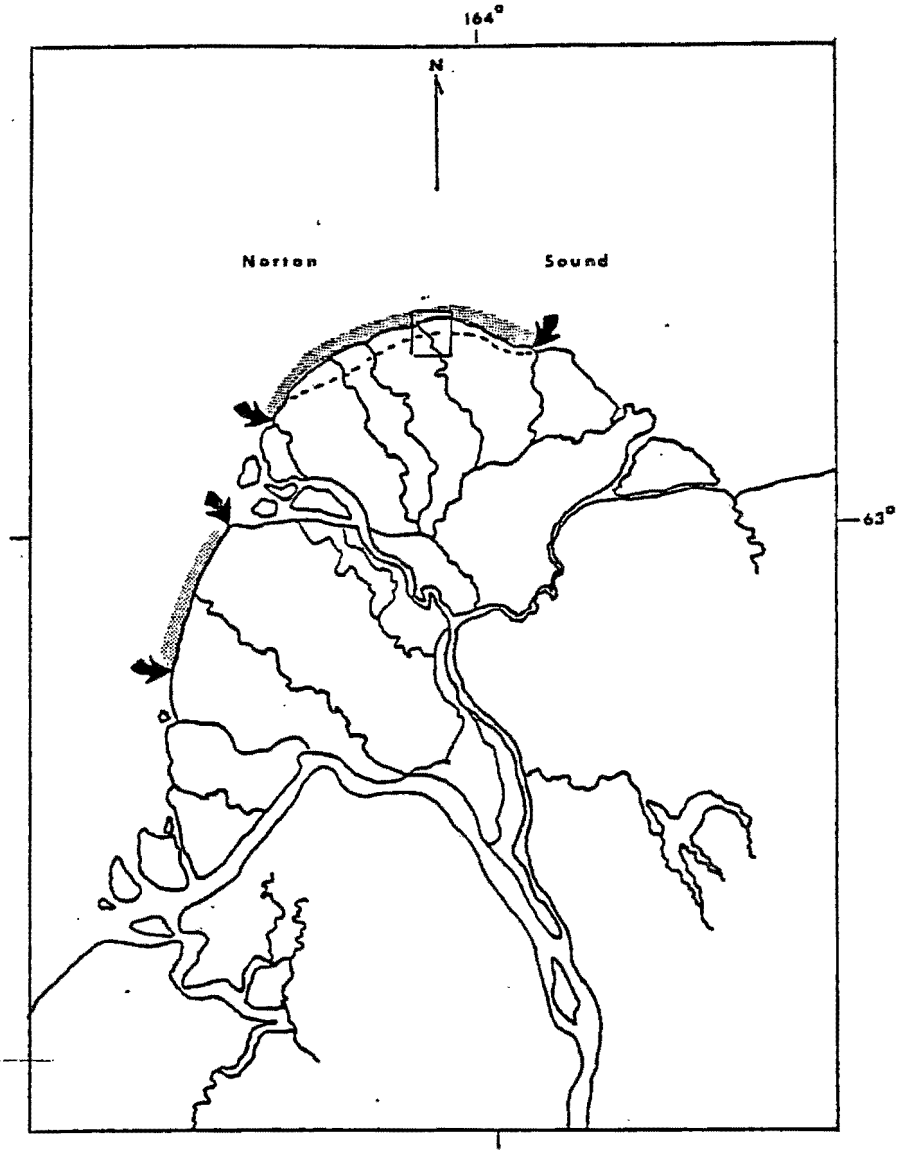


The Uwik Slough Study Area

1 Km

From Aerial Photography

Fig.3

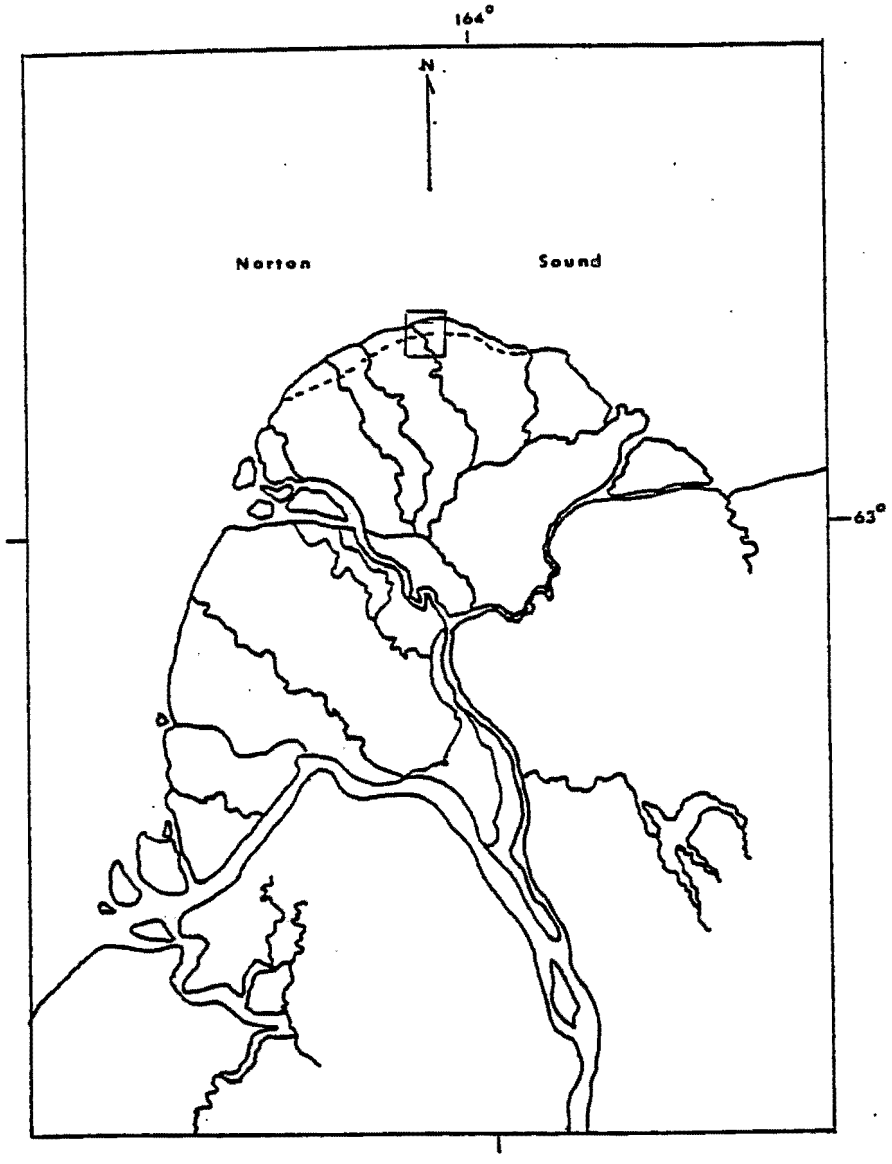


The Yukon River Delta

Showing zones of relative water clarity

From Satellite Imagery

Fig. 2



The Yukon River Delta

From Satellite Imagery

Fig 1.

		6/10-6/17	6/18-6/25	6/26-7/3	7/4-7/11	7/12-7/19	7/20-7/27	7/28-8/4	8/5-8/12	8/13-8/20	8/21-8/28
WHIMBREL		2.22	2.45	1.19	2.01	1.61	1.44	1.14	.88	1.50	.40
	AVG. NUMBER	0.000	0.000	1.600	2.750	0.381	0.083	0.000	0.000	0.000	0.000
	FREQUENCY	0.00	0.00	0.12	0.50	0.24	0.08	0.00	0.00	0.00	0.00
DUNLIN											
	AVG. NUMBER	4.077	11.545	1.360	1.250	0.571	0.542	0.043	1.000	2.375	1.130
	FREQUENCY	1.00	0.91	0.64	0.46	0.43	0.42	0.04	0.35	0.33	0.43
LB DOWIT.											
	AVG. NUMBER	0.000	0.000	0.080	1.083	1.190	1.750	0.087	1.348	10.292	2.652
	FREQUENCY	0.00	0.00	0.04	0.25	0.38	0.75	0.09	0.61	0.96	0.65
SP SANDP.											
	AVG. NUMBER	1.308	4.864	0.400	0.292	0.524	2.250	0.000	0.783	0.125	0.609
	FREQUENCY	0.54	0.68	0.24	0.21	0.24	0.63	0.00	0.48	0.08	0.13
BT GODWIT											
	AVG. NUMBER	0.846	0.227	2.440	0.667	0.000	0.000	0.130	0.652	0.458	0.000
	FREQUENCY	0.46	0.14	0.40	0.21	0.00	0.00	0.09	0.39	0.13	0.00
H GODWIT											
	AVG. NUMBER	0.308	0.000	0.400	2.125	1.762	0.000	0.000	0.043	0.000	0.000
	FREQUENCY	0.08	0.00	0.12	0.29	0.38	0.00	0.00	0.04	0.00	0.00
R PHALAR.											
	AVG. NUMBER	13.308	0.409	0.120	0.000	0.095	0.000	0.000	0.000	0.000	0.000
	FREQUENCY	0.92	0.18	0.12	0.00	0.05	0.00	0.00	0.00	0.00	0.00
N PHALAR.											
	AVG. NUMBER	5.385	10.818	6.640	14.708	13.810	11.833	12.652	6.217	3.833	0.087
	FREQUENCY	0.85	1.00	1.00	0.96	1.00	1.00	0.96	0.96	0.50	0.09
AM AVOC.											
	AVG. NUMBER	1.462	1.909	1.720	0.333	0.190	0.375	0.522	0.435	0.208	0.522
	FREQUENCY	0.85	0.73	0.48	0.38	0.14	0.13	0.09	0.13	0.13	0.22
SAV SPAR.											
	AVG. NUMBER	0.154	0.318	0.520	0.208	0.000	0.292	0.087	0.304	0.292	0.739
	FREQUENCY	0.15	0.18	0.36	0.17	0.00	0.13	0.09	0.26	0.21	0.35
LAP LONG											
	AVG. NUMBER	0.769	1.909	0.320	0.083	0.048	1.000	5.217	12.217	36.083	16.913
	FREQUENCY	0.31	0.73	0.20	0.08	0.05	0.54	0.70	1.00	1.00	1.00
number of transects:		(14)	(22)	(25)	(24)	(21)	(24)	(23)	(23)	(24)	(23)

CENSUS FIG... OVER MONTHLY AND WHOLE SUMMER TIME PERIODS,
JUNE-AUGUST, 977 - YUKON RIVER DELTA
TRANSECT B

SPECIES		JUNE	JULY	AUGUST	JUNE-AUG
LB DOWIT	AVG NUMBER	0.000	1.056	4.108	1.955
	FREQUENCY	0.00	0.37	0.65	0.390
SP SANDP	AVG NUMBER	2.660	0.811	0.422	1.081
	FREQUENCY	0.54	0.29	0.19	0.310
W SANDP	AVG NUMBER	0.966	0.089	0.313	0.368
	FREQUENCY	0.18	0.03	0.04	0.070
BT GODWIT	AVG NUMBER	0.640	0.678	0.349	0.547
	FREQUENCY	0.30	0.10	0.17	0.170
H GODWIT	AVG NUMBER	0.080	1.089	0.012	0.462
	FREQUENCY	0.02	0.20	0.01	0.090
R PHALAR	AVG NUMBER	3.800	0.022	0.000	0.861
	FREQUENCY	0.40	0.01	0.00	0.090
N PHALAR	AVG NUMBER	7.540	13.411	4.181	8.659
	FREQUENCY	0.96	0.99	0.58	0.830
PAR JAEGER	AVG NUMBER	0.240	0.033	0.000	0.067
	FREQUENCY	0.18	0.03	0.00	0.050
SAB GULL	AVG NUMBER	0.940	0.267	0.000	0.318
	FREQUENCY	0.28	0.07	0.00	0.090
AR TERN	AVG NUMBER	1.560	0.856	0.217	0.776
	FREQUENCY	0.72	0.43	0.10	0.370
SAV SPAR	AVG NUMBER	0.360	0.178	0.398	0.300
	FREQUENCY	0.24	0.11	0.25	0.190
LAP LONG	AVG NUMBER	1.160	0.422	19.843	7.816
	FREQUENCY	0.46	0.26	0.98	0.570
number of t... counts:		(50)	(90)	(83)	(223)