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A Report to the University of Wisconsin
Sea Grant College Program

THE APOSTLE ISLANDS: CONCENTRATION AREA FOR
MIGRATORY BIRDS IN SPRING

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BACKGROUND

In many areas of the world, large bodies of water have major impacts on land bird migration (Rudebeck, 1950; Dobben, 1953; Dorst, 1962). In North America most coastlines tend to run north to south, along the major flight directions. But Lake Superior extends nearly four hundred miles east to west, directly across a portion of the heavily used Mississippi flyway. Birds as weakly winged as the rails or as small as the five-inch-long warblers must cross this frequently stormy barrier, or else travel far out of their way east or west to bypass the water crossing.

Along coasts in some regions the water barrier funnels migrants onto peninsulas or islands, and at the farthest protrusion of land, great concentrations of birds occur. These sites represent critical resting and feeding areas, and often have been given protection as wildlife sanctuaries. They are ideal locations for study of migrant behavior at the water-land interface. In addition, such focal points have a special attraction for naturalists and bird watchers -- their value for recreation is high.

The reaction of migrants to water extending across their line of flight varies from location to location and is significantly modified by wind speed and direction. At Cape May, New Jersey with a northwest wind, migrants are halted by the end of the cape and will even fight the wind to return up the inner shore (Allen and Peterson, 1936). However, when the wind dies or shifts, many hawks will cross directly over Delaware Bay toward Delaware. Schorger (1965) found that blue jays* even hesitated before the 1.7 mile crossing of Lake Mendota in Wisconsin, spiraling high before venturing over the water.

But passerines and hawks are known to make routine water crossings over very long distances. Migrants cross hundreds of miles of open water from the Texas and Louisiana coasts to the Yucatan (Lowery, 1945). Good evidence exists indicating that blackpoll warblers fly directly from New England to the Lesser Antilles or beyond (Nisbet, Drury, and Baird, 1963). Accipiters and falcons, along with many passerines, cross from at least as far south as Cuba to northern Florida, often passing the Dry Tortugas without even stopping (Daniel Berger and George Allez, personal communications). Generally water seems to act less

*Scientific names of all bird species sighted during this study are included in Appendix C. The main text contains scientific names only for species we did not see in the Apostles.

as an absolute barrier than as an impediment to migration. The birds hesitate by the shore, reluctant to leave land and perhaps even taking false starts over the waves; they await highly favorable weather conditions (Rudebeck, 1950; Able, 1972).

Birds of different species, or even the same species, react differently to a coastline. Lack and Lack (1952) noted skylarks Alauda arvensis in good numbers traveling in five directions at one location in southwest Britain. In England, starlings show less hesitation before a sea crossing than do smaller passerines (Snow, 1953). Night-flying migrants do not normally follow coastlines (Lack, 1959).

Leading lines are prominent topographical features or abrupt changes in habitat (such as land to water) which birds tend to follow in their migration instead of pursuing a constant direction, regardless of the topography below (see discussion in Mueller and Berger, 1967b). Mueller and Berger consider the effectiveness of a leading line to depend on several factors: linearity, length, angle formed by the leading line and direction of flight, prominence of the line, birds' motivation to migrate, wind direction, time of day, and height of flight. Under certain meteorological conditions, air movements along mountain ridges, or along shorelines, favor hawk flight and will be traveled by many migrants (Haugh, 1972).

The higher a migrant is flying, the less influenced it will be by a coastline (Rudebeck, 1950). In general, the stronger the wind, the lower the height of flight. The height is greater with following winds than with head winds (Snow, 1953).

Even the relatively narrow Great Lakes greatly influence migration. Large numbers of migrants are known to concentrate at certain points along every lake. Point Pelee, near the northwest end of Lake Erie, is renowned for its spring and fall bird flights. The migrants make their lake crossing where the point and several islands leave no long stretches of water (Taverner and Swales, 1907). While most buteos pass round the west end of Lake Erie (Haugh, 1972), some rough-legged hawks, and many accipiters and falcons cross at Pelee (Taverner and Swales, 1907; Kleiman, 1966). Unlike most passerines, they cross the lake directly, not flying from island to island.

Heavy flights of blue jays have been observed along Lake Erie (Plunkett, 1969) and of black-capped chickadees along Lake Ontario (Bagg, 1969); suggesting that these species do not readily cross the lakes. In spring, hawks travel along the south shores of Erie and then Ontario in a northeasterly direction, some of them perhaps traveling as far as 300 to 400 miles along the lakes before at last reaching the northeast end of Ontario (Haugh, 1972). But at Prince Edward Point, on the north side of Lake Ontario a short way west of the lake's northeast end, some hawks appear from over the lake, having made a 30 to 35 mile crossing. Peak numbers occur later in spring than peaks at Derby Hill on Ontario's south shore, suggesting that delayed migrants may cross water to shorten their migratory flight (Weir, 1972). Passerines also concentrate at the east end of Prince Edward Point, traveling southwest along the point's north shore, rather than north across the water to return to the mainland.

Shores of Lakes Huron and Michigan also receive heavy land bird flights. Sand Point, Fish Point, and Tawas Point on Lake Huron are particularly known (Dorst, 1962; Kelley and Kelley, 1973). But the largest concentrations appear on the southwest end of Lake Michigan, along the heavily urban waterfront at St. Joseph and Benton Harbor (Booth, 1969 and 1971). Here, it is not unusual to see 5,000 migrants pass by in a few hours, or, several times a year on a single day, to see 10,000, 20,000, or 40,000 birds. Day-flying migrants dominate the flight here, especially jays, blackbirds, starlings, and swallows.

Observation of migration along Lake Superior has been sporadic. Both the west and east ends of the lake receive heavy flights. Whitefish Point, near the southeast end of the lake, has long been known for its spring flights (Magee, 1922). Both passerines and hawk migrants concentrate here before crossing twenty miles of water northeast to Canada. According to Tyrell (1934), hawks here await a headwind before leaving the point. Many species of hawks occur here regularly in large numbers (Kelley, 1972), while owl migrants of six species have been reported, including the rare boreal owls Aegolius funereus (Kelley and Roberts, 1971). Passerine counts are also at times impressive; 10,000 purple finches on each of several days in 1973, and 29,000 evening grosbeaks during a week that same spring (Kelley, 1973). South of Whitefish Point, many migrants cross the Straits of Mackinac (Merriam, 1885; Sheldon, 1965), although others pass along the north shore of Lake Michigan in or out of Wisconsin (Beebe, 1933).

The hawk flights at Duluth are among the largest on the continent (Heintzelman, 1975). The biggest counts occur in the fall, but good numbers -- not including broad-winged hawks -- come out of Wisconsin in the spring (Hofslund, 1966).

Hawk movements in the middle portions of Lake Superior are poorly known, not receiving any systematic study until 1976 and 1977, when Frank Isaacs (personal communication) began observations at Keweenaw Peninsula. The counts at either end of the lake, as well as Postupalsky's (1976) observations of bald eagles and other raptors following the shore in Wisconsin and western Michigan, suggest that many if not all hawks avoid a wide water crossing. But Wood (1933) reported raptors in the hundreds -- including rough-legged, red-tailed, broad-winged, Cooper's, and sharp-shinned hawks -- leaving the end of Keweenaw Peninsula, to fly 6 miles east to Manitou Island, and finally, to head 75 or more miles north across Superior to Canada, apparently passing east of Isle Royale.

Mueller and Berger (1967a) speculated that in spring the south shoreline of Superior gathers and directs hawks across the lake at Bayfield and Keweenaw Peninsulas as well as at Whitefish Point. But in fall, the north shore may lead hawks around the lake instead, except perhaps at Isle Royale. Binford (1965) noted sizable early autumn flights in Keweenaw; these could simply be northward wanderings of immatures. Walter Hasting (vide Sheldon, 1965) did report many raptors arriving at Manitou Island from over the lake. The situation in the Keweenaw area needs more observation.

The Apostle Islands area has not been studied. Perkins (1964), after many years of commercial boating experience on the Great Lakes, identified narrow sections across the lakes where the greatest numbers of migrants cross. He described the waters off the Apostle Islands as the location of "one of the heaviest traveled flyways over the Great Lakes." Peet (1908) believed the autumn migration from Isle Royale across Superior to go more southwest towards the Apostles than south to Keweenaw.

The wide lake crossings can indeed be difficult for migrants, with storms causing mass fatalities (Green, 1962); Perkins, 1964).

The Apostles lie to the north and northeast of one of the longest protrusions of land into Lake Superior (see Figure 1). Many birds traveling the westerly or southerly winds in spring probably follow the south shore which slants northeast from Duluth all the way to the end of Bayfield Peninsula. The inner islands lie just beyond. The outer islands provide the last resting place. During the spring of 1974, I observed large numbers of migrants on little Devil's Island. Northern hardwoods that totally cover the island sheltered species of birds normally inhabiting open fields and marshes.

I chose Outer Island (see Figure 2; place names on the map are used during the remainder of the report) as my 1976 study site because of its position as the island farthest north and east of the Apostles. Its size is small enough to allow convenient coverage of the migration, but large enough to include varied habitats, shorelines, and exposures. This island, unlike any of the other northern islands, has areas of marsh, grass, and wide, sand shore. Migrants of many species will not find any other suitable habitat nearby.

In 1977, I extended the scope of the study to include brief observations on Devil's, Stockton, and Michigan Islands, as well as a second season's coverage on Outer Island. During this spring, I documented in detail flights on Outer, and obtained basic data for outlining migratory patterns elsewhere in the island group.

Various approaches are needed for the study of migration in the little known Lake Superior region. I planned intensive observations at one location not only because the Apostle Islands deserve assessment as a valuable resource, but because I wished to obtain data from one site as the season and weather conditions changed. Extensive studies over long stretches of shore can provide data on utilization of different habitats or the passage of certain groups of birds, but, due to practical funding limits, such projects cannot document with any precision the effects of the lake barrier.

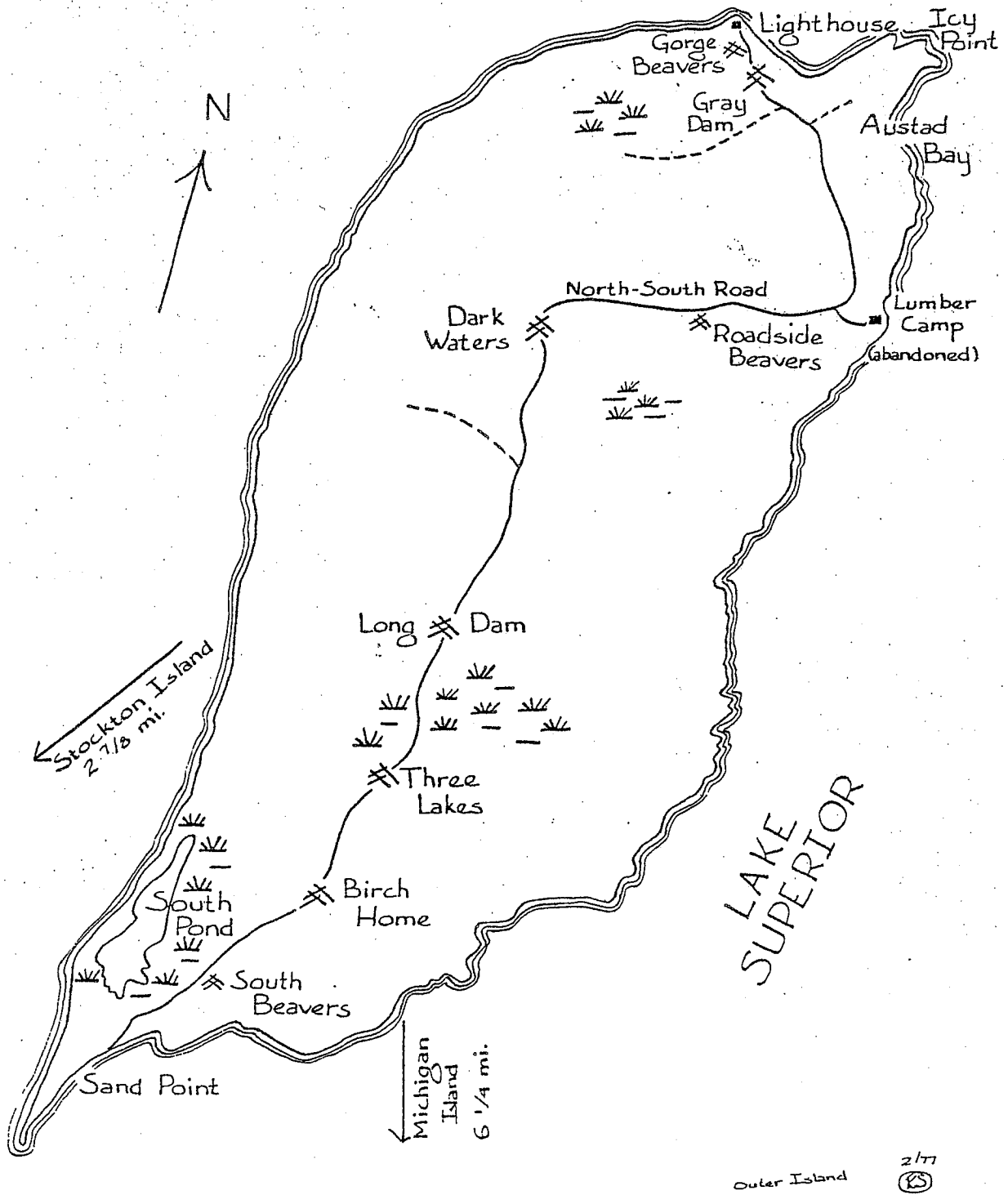


Figure 2. Outer Island

STUDY SITE

Lake Superior has the largest surface area of any fresh water lake in the world and, with a mean depth of 489 feet, it has the second greatest volume. Its waters are clear and cold. Because of the naturally low levels of dissolved minerals and nutrients, biological productivity is low. This remote lake remains remarkably unpolluted.

The region has a continental climate, with four distinct seasons. Up to six months of the year have mean daily temperatures below freezing. Arctic air masses frequently chill the region in winter, with temperatures falling as low as -40 to -50° F. Summers are short. Along the south shore, at times only 5 months have mean daily temperatures over 50° F. Low pressure systems, originating far to the west, often pass over Superior, with storms brief but intense.

The large mass of water has a marked effect on weather. Air temperatures can be modified up to 20° F as far as 20 miles inland, being milder in winter and cooler in summer. Spring emergence of vegetation comes markedly later in the outer Apostles than in interior, mainland areas. The cool lake increases frequency of fog in spring and summer, with near-shore areas experiencing 30 to 50 days of fog annually (Lake Superior Project, 1972-73).

The Apostle Islands lie at 47° N and $90^{\circ}45'$ W. Twenty-two islands are included in the group, twenty of which are part of the Apostle Islands National Lakeshore. Outer Island is farthest from the mainland, fifteen miles off Red Cliff Point, while York Island lies only one mile off Point Detour.

Outer Island has a size of 7,999.6 acres, third largest of the Apostles, with maximum dimensions of 6.9 by 2.6 miles. The islands closest to Outer include Michigan (6.1 miles to the south), Stockton (2.7 miles to the south-west), and Cat and North Twin (3.8 miles, and 6.1 miles to the west). Highest elevation occurs near the island's center, about 275 feet above Lake Superior's surface. Almost the entire island is thickly forested, so that travel is impractical except over short stretches of the shoreline and along a partially overgrown network of lumber roads. The main route from the south tip to the lighthouse at the north end and the old lumber camp on the northeast shore remains plain and easy to follow, but most side paths have nearly disappeared.

The lumber camp was active as recently as 1960. The forest is young, with generally only a scattering of trees taller than forty feet. Maples,

aspens, and birches are dominant. Hemlock, white cedar, Balsalm fir, and white pine grow in much lesser numbers, with conifers dominating only isolated areas. Small trees, with basal diameters of four inches and less, are abundant below the forest canopy.

Non-forest habitat is limited. Small human-created clearings remain about the lighthouse, the lumber camp, at one interior location, and at two places near the island's south end. Beaver are numerous. Their colonies have opened and flooded the forest at many locations, including seven places along the north-south road.

The only land permanently open, with the exception of very narrow strips of sand beach or rock ledges, occurs at the south end, where beaches are wide and sparsely vegetated. Upper portions of the 1 1/2-mile-long west beach provide grassland habitat. The adjacent forest, growing on a sandy soil, is diversified by frequent clearings. Three quarters of a mile north of the south tip, a lake and bog (called South Pond in this report) is separated from open Superior by a narrow isthmus of sand.

Stockton (10,053.7 acres) and Michigan (1,581.6 acres) also are dominated by northern deciduous forests. Stockton lies directly between Outer Island and Bayfield Peninsula, near the center of the Apostles. It is closest to Hermit Island, 1.6 miles to the southwest. Michigan lies at the southeast edge of the Apostles, 2.6 miles from Stockton and 3.2 miles from Madeline Island.

Stockton has been thoroughly described by Stadnyk, Verch, and Goetz (1974). This second largest of the Apostles was logged less recently than Outer, so that the forest is older and most of the old roads gone. Several man-made clearings remain, two of them on the south shore with docks and campgrounds. The National Park Service maintains several trails and will be creating more soon. In addition to beaver openings, a large bog at Presque Isle Bay offers sheltered aquatic habitat. The areas around it contain a scattering of conifers somewhat like the south end of Outer. A sand beach edges the lakeshore just east of the bog.

Stockton's shore nearest Outer Island rises abruptly in short rock cliffs. Except at Trout Point, a little to the west, this entire area is heavily overgrown, so that observations are difficult.

Michigan Island is similarly overgrown, except for a wide beach at its southwest end. There is a bog near this beach, similar to but smaller than the bogs on Outer and Stockton. There is no area here of broken forest and grassy clearings.

The lighthouse on the south of Michigan has a small lawn. Hiking is easy along most of the southeast shore, but I could find no trail. Just northeast of Michigan Island lies Gull Island, a 3.4 acre pile of rocks supporting a 600-pair colony of nesting gulls (Harris and Matteson, 1975).

Devil's Island (318.0 acres) lies as far north as the north end of Outer but is 12.5 miles to the west. Southeast of Devil's 2.1 miles is

Rocky Island, while Bear Island is 2.5 miles southwest, and Otter 3.9 miles to the south.

Devil's lacks any clearings, except around the lighthouse at the north end. Unlike most of the other Apostles, Devil's forest has strong boreal elements. We did not find beaver here, but the island interior contains standing pools of water and a small bog sparsely grown up with spruce. Devil's shores all are rocky, except for a tiny beach by the south end pier. Devil's Island measures only 1.3 miles long by 0.5 wide.

METHODS AND DATA

Observation of birds as they are actually migrating has frequently formed the basis of studies in Europe (see Thompson, 1953), with valuable results. In North America, such studies have been less systematic, except for investigations of raptor movements (see Heintzelman, 1975). These methods have a serious drawback: substantial evidence exists that great numbers of birds travel at altitudes too high to be seen from the ground (Lack, 1960a, 1960b; Eastwood and Rider, 1965). Moreover, conclusions drawn from direct observations and from radar, which detects high-flying birds, can be contradictory. Evans (1966) in Northumberland, England, used both methods, finding that birds flying within visible range of the ground were too low for radar to detect. His observations suggest that almost all diurnal migrants changed their flight direction to follow the coast if they were low enough to be seen, while almost all went out to sea if high enough to be picked up by radar.

Wilcock (1964) in Norfolk, England, also found behavior of high- and low-flying migrants to differ. At times, the high birds would be flying offshore with strong following winds, while birds coming inshore would be flying low against the headwind. Evans (1966) believes this tendency for birds to fly low against a wind has led observers relying only on direct visual methods of study to conclude migration is commonest with headwinds.

However, if the limits of direct visual observations are remembered, such methods can have advantages over use of radar. Visual studies require no expensive, difficult-to-obtain equipment. Observations can easily be taken in remote areas, or from many places simultaneously. And migrants usually can be identified to species, or at least family -- this cannot be done with radar. The precise, low level data obtained by direct observations cannot be matched by radar.

For the present study, I relied almost entirely on direct observations of birds in flight. Observation periods lasted a half hour, and were frequently in consecutive or near-consecutive series. Most data were collected in early morning, with additional periods scattered through the day. Numbers of land birds (water birds were generally not counted), species (or genera or families), flight directions, responses to water, and general behavior were recorded. Data were taken by one or two persons stationed at places with good views of both lakeshore and island. Other studies have relied on binoculars (Wilcock, 1964) and spotting telescope (Forsyth and James, 1971) aimed toward the zenith, but I seldom used either instrument

except to identify a bird already detected. Unless otherwise noted, all data represent birds detected without optical equipment. Use of binoculars would have limited view to a small proportion of the sky, and the great majority of migratory activity at any one time would have been unnoticed.

I observed the migration in both 1976 and 1977 from late April until early June, for about 5 1/2 weeks each season. Due to the dangers of boating before the lake ice had melted, early portions of the migration were not observed. The study extended almost to the end of migratory activity.

In 1976, I camped alone on Outer Island from April 26 until June 3. I spent a limited amount of time along the island's northeast shore, otherwise dividing my observations between the lighthouse at the north end and Sand Point and the bog at the south end.

In 1977, my assistant, Michael John Jaeger, and I arrived on Outer Island on April 28. Jaeger remained on Outer throughout this season's study, but I traveled to Stockton Island on May 13. On May 25, three additional observers joined Jaeger on Outer, while one person began data collection on Michigan Island. With one companion, I moved to Devil's Island on May 26. All observers left the islands on June 3.

Observation sites on the eastern Apostles are depicted in Figure 3. In 1977, observations at Outer were taken at the lighthouse and Austad Bay areas in the north, and at the south end. Stockton Island data came from several look-outs on Presque Isle Point and on the island's rocky northeast shore. Other parts of Stockton were not visited. Michigan Island data were taken primarily from the southwest end -- from the sand beach, from near the bog, and from atop the lighthouse. The island's east end, closest to Gull and Outer Islands, was briefly visited. Observations at Devil's were taken from the breakwater on the north, and from the west shore, near the south end. Interior portions of the island were frequently visited.

In 1976, I observed migrants in flight for eight half-hour periods at the north end of Outer and for thirteen half-hour periods at Outer's south end. In 1977, a total of 429 half-hour periods were recorded, including 175 periods at south Outer, 54 at Outer's lighthouse, 32 at Austad Bay, 36 on Stockton Island's Presque Isle Point, 28 from northeast Stockton, 34 from southwest Michigan Island, 42 from Devil's Island's south end, 7 from west Devil's, and 21 from the Devil's lighthouse.

In 1976, to supplement flight observations, I took sample counts of bird densities on the ground in varied habitats. On both north and south Outer I set up sixteen count stations. Six of the northern stations clustered about the lighthouse clearing, while the other ten were scattered along the lumber road south, half in places partially cleared by beaver and half in undisturbed forest. The southernmost was a mile from the lighthouse.

The south end stations lay in a 1 1/2-mile-long horseshoe along the east and west island shores and extended a short distance inland, to include portions of bog, beach, grassland, coniferous and deciduous forest, and beaver clearing.

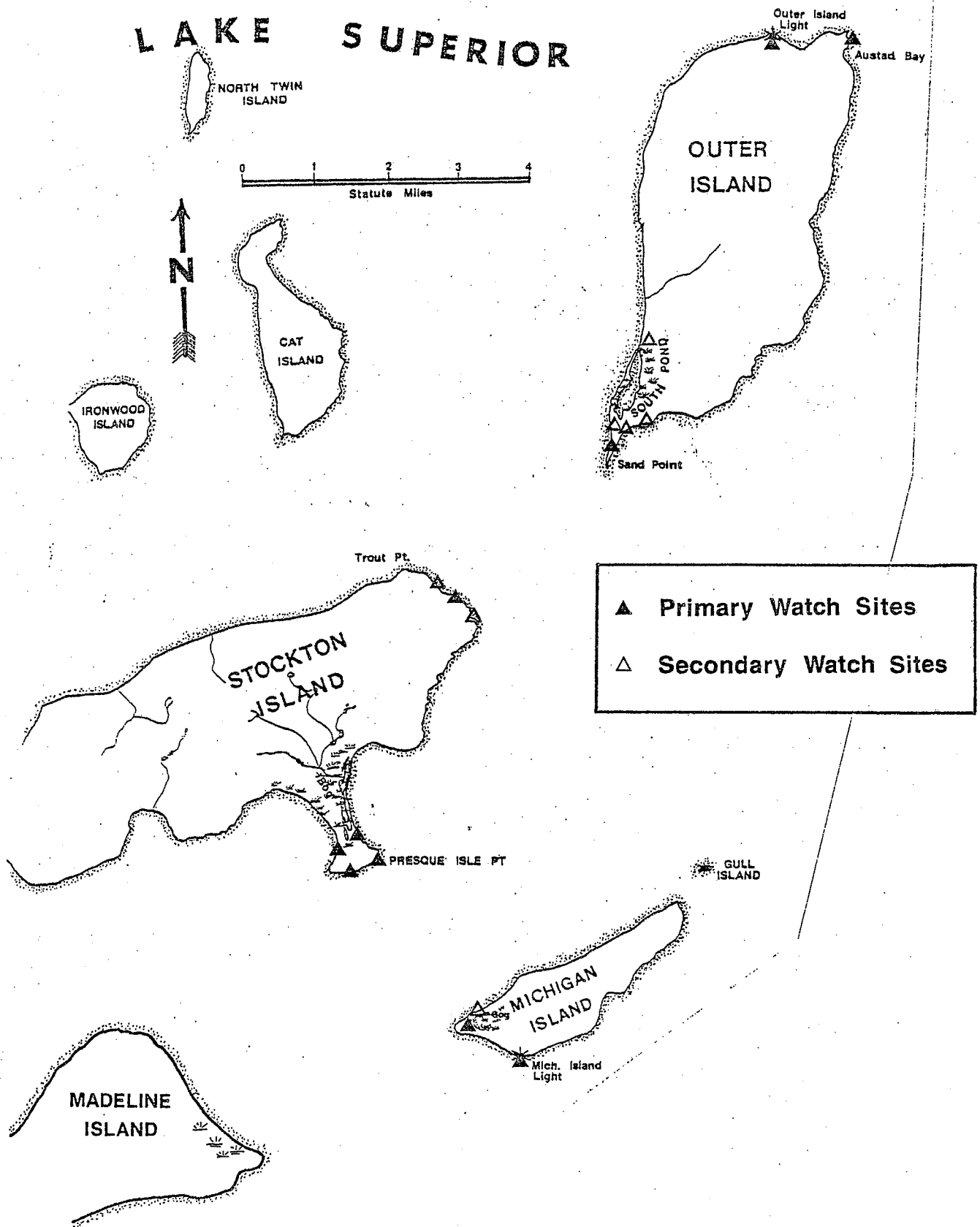


Figure 3. Observation Points in the eastern Apostles.

I visited only one set of sixteen stations in a morning. The count period began 1/2 to 3/4 of an hour after sunrise, lasting about three hours. Each station consisted of a square 100 meters by 100 meters, for an area of one hectare. I would begin at the midpoint of one side of the square and walk to the station's center (see Figure 4), counting all birds seen (with or without binoculars) or heard within a three-minute period. The terrain and dense vegetation would have made walking through the entire length of the station impractical at many sites.

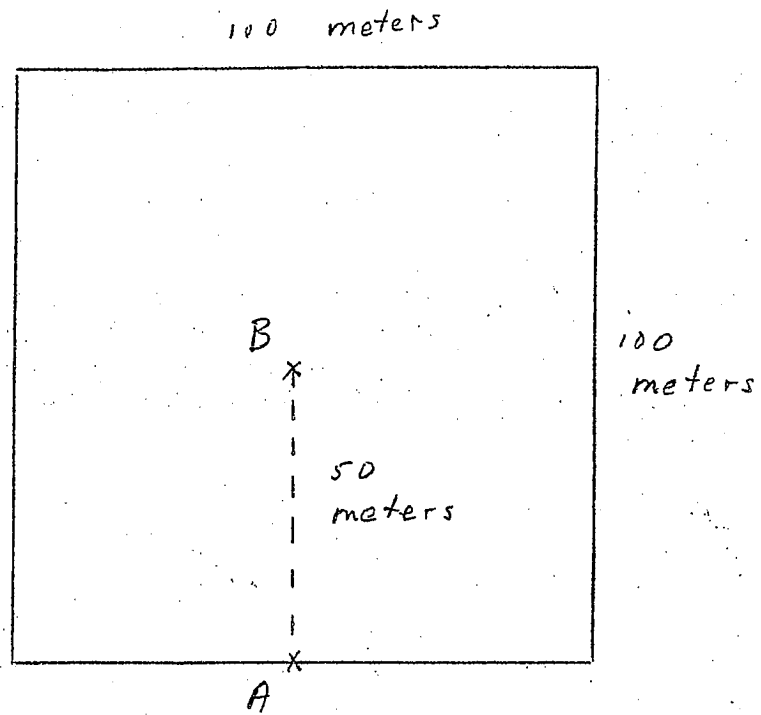
The sixteen count stations were visited thirteen mornings at the north end and ten mornings at the south end.

In addition to systematic data collection, we spent hundreds of hours while living and walking about the islands recording both land and water bird activity at many parts of the island shorelines and interiors. Shorebirds were particularly attracted to the sandy south tip of Outer Island. In 1976, I took shorebird censuses here on eight days between May 14 and June 2.

Hawks were noted during all observations of migration. In addition, some watches were made solely for hawks, at times when hawks were moving. I used binoculars for scanning the sky, and, in 1976, a 20X spotting telescope at Outer's lighthouse. Twenty-three hours of hawk observation were recorded in 1976, and 29 3/4 hours in 1977.

Weather data have been taken from the Daily Weather Maps, published by the United States Weather Bureau. The hourly weather observations made by the United States Coast Guard at Devil's Island provided a record closely corresponding to actual conditions on Outer and the other islands. During observations, we noted temperature, wind speed and direction, cloud cover, precipitation, and visibility.

Winds were generally measured at 4 to 6 feet above ground level. Even sparse vegetation may slow low level winds slightly, so that our readings were probably a little slower than the wind speeds birds in flight encountered. Similarly, wind direction can vary with altitude. I can't estimate the extent to which this occurred in the Apostles, although most birds noted were low enough to make drastic disparities in wind direction unlikely.



A. Start

B. Finish

Figure 4. A Morning Count Station

MIGRATING HAWKS

The Apostle Islands host hawk flights of considerable size. During the two-season study, 6,523 individual hawks, vultures, and eagles were counted, of fourteen species. In Table 1 I list the species in order of abundance. The direction and magnitude of hawk movements observed among the eastern Apostles are shown in Figure 5.

The broad-winged hawk was the dominant species, comprising nearly 3/4 of the total number of raptors observed. In 1976, counts of this species surpassed one hundred on 6 days between April 29 and May 20. In 1977, counts surpassed one hundred on 8 days between April 30 and June 3. The species frequently traveled in flocks, with several hundred birds sometimes visible at once.

Sharp-shinned hawks were easily the second commonest species, with over fifty counted on 4 days between April 29 and May 8 in 1976, and also on 4 days between May 1 and May 12 in 1977. They appeared most often singly or in pairs, but sometimes small numbers, up to thirteen, traveled in loosely associated flocks.

Numbers were far smaller for all other species, although most red-tailed and rough-legged hawks, goshawks, and bald eagles probably migrated before our observations began. In early parts of April 1976, Frank Isaacs (personal communication) observed large hawk flights, predominantly of red-tailed, on Keweenaw Peninsula.

During the two seasons, over two hundred hawks were observed on 11 different days. On all of these days, winds as recorded at 4 to 6 feet above ground level were out of the west or southwest. Wind speeds were at 8 MPH or greater on 8 days, and at 7 MPH on 2 others. The eleventh day, with the highest hawk total of all, in the mid-morning, had nearly calm conditions, but the day before a strong southwest wind had concentrated hawks on Outer Island at nightfall, as will soon be described. Haugh (1972) found that southeast winds concentrated the hawks as much as southwest winds at Derby Hill on the south side of Lake Ontario. But on Superior hawks are much likelier to pass out the northeast tending Bayfield Peninsula and then on to the eastern Apostles, with westerly winds. Stronger winds yield higher concentrations.

Because of the timing of our observations, the vast majority of hawks were recorded from Outer Island. The top of Outer's lighthouse offered a

Table 1. Migrant Diurnal Raptors in the Apostle Islands

<u>Species</u>	<u>Two- Year Total</u>	<u>1976 Total</u>	<u>1977 Total</u>	<u>Peak Count 1976</u>	<u>Peak Count 1977</u>	<u>Peak Date 1976</u>	<u>Peak Date 1977</u>
Broad-winged	4,804	2,451	2,353	830	420	May 4	May 23
Sharp-shinned	1,230	448	782	106	146	April 30	May 5
Red-tailed	151	45	106	9	19	May 8	May 1
Kestrel	106	58	48	17	9	April 30	May 1
Marsh harrier	57	17	40	4	9	May 8	April 29
Turkey vulture	55	27	28	8	6	May 28	May 1
Rough-legged	48	27	21	13	10	April 29	May 1
Cooper's	37	27	10	7	4	April 29	May 1
Osprey	14	5	9	1	2	April 30 May 4 May 8, 10, 11	April 30 May 25
Bald eagle	9	4	5	1	3	April 26 May 4, 8, 15	April 30
Merlin	7	4	3	1	1	April 29 May 1, 4, 13	May 3, 4 10
Red-shouldered	3	1	2	1	1	May 8	May 12, 16
Goshawk	1	1	0	1	0	April 29	--
Peregrine falcon	1	1	0	1	0	May 10	--
All Species	6,523	3,116	3,407	854	429	May 9	May 23

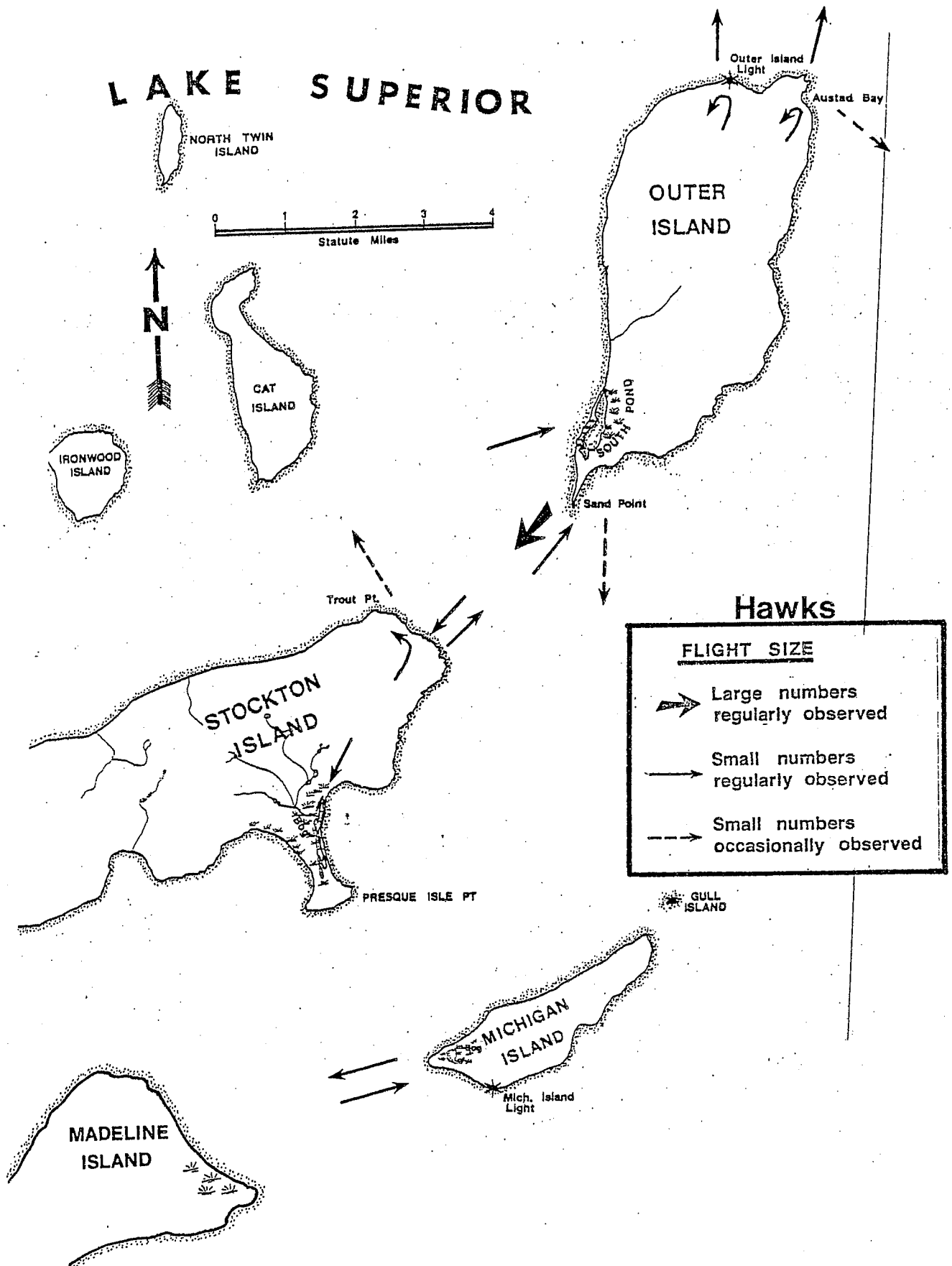


Figure 5. Patterns of Observed Hawk Migration -- Outer, Stockton, and Michigan Islands.

particularly good observation point. From here, hawks appeared to be traveling north over all portions of the island's interior, without exhibiting any tendencies toward a particular route.

Upon encountering the open Lake Superior, even on days when the Minnesota shore to the north was clearly visible, almost all hawks altered their flight direction and refused to cross the lake. Some followed Outer's shore east where the land extended in a point a short distance north. Many of these could later be seen passing south far to the east of the lighthouse. Many hawks immediately turned about at the lighthouse and fought the winds, which had previously favored their movement, to return the way they came. A few traveled west, presumably turning south as Outer's shore bent in that direction.

Hawk behavior at Austad Bay was similar, with almost all migrants turning when they encountered the lake, to follow the shore west or south, or retreat southwest over the forested interior. On May 5, 1977, one hour of concurrent observation was made at the lighthouse and at Austad -- for this watch Austad had 53 sharp-shinned and 79 broad-wingeds, as compared with only 23 sharp-shinned (and no buteos) at the light. But in general, perhaps because of the superior view from atop the tower, hawk numbers were greater at the light. An average of 24.6 hawks per hour were sighted there, with just 13.5 per hour at Austad.

A limited number of hawks did fly out over the lake. In Table 2, behavior of hawks in 1977 at the lakeshore is listed for 56 1/2 hours of observation. Only sharp-shinned hawks, falcons, and once an osprey attempted a lake crossing, while all other species turned around. This result is very similar to Perkins' (1964, 1965) conclusions after many years of open water observations: kestrels, merlins, and sharp-shinned frequently appeared over the Great Lakes, but Perkins never saw a red-tailed or broad-winged hawk.

Most of the crossings we saw in the Apostles were initiated with winds from a southerly direction, or from the west. But several raptors flew against a light northerly wind. One kestrel headed swiftly into a 12-16 MPH wind, while the osprey confronted a 10-12 MPH wind.

Birds attempting to cross the lake were followed in binoculars until they vanished from sight. Others were seen turning back a short distance from shore. Probably some hawks listed in Table 2 as crossing actually abandoned their attempt. On May 5, 1977, 9 sharp-shinned hawks flew north out of sight from the lighthouse; during the same hour, 4 sharp-shinned were first spotted flying south off the lake at Austad.

More definite documentation of lake crossings could be obtained by radio tracking of tagged birds, use of radar, or by sighting the birds arriving at Superior's north shore from over the lake. My sightings of kestrels, and particularly 2 peregrines and 4 merlins (two species that do not now nest south of Superior) on Michigan Island in September 1976 provide additional evidence that hawks do cross this part of Lake Superior.

Table 2. Raptor Response to the Lakeshore on North Outer Island, 1977*

<u>Species</u>	<u>Number Turning at Shore</u>	<u>Number Crossing Lake</u>	<u>% Crossing Lake</u>
Turkey vulture	5	0	0
Sharp-skinned	191	36	5.9%
Accipiter sp.	2	0	0
Red-tailed	4	0	0
Broad-winged	904	0	0
Buteo sp.	12	0	0
Marsh harrier	3	0	0
Osprey	1	1	50%
Merlin	2	0	0
Kestrel	7	1	13%
Falcon sp.	1	2	67%
Unidentified	4	0	0
Total	1136	40	3%

* Based on 56 1/2 hours observation: 37 at the lighthouse and 19 1/2 at Austad Bay.

Possibly my observations underestimate numbers of hawks crossing, for those flying highest, and therefore hardest to detect, might be least affected by the lakeshore.

Outer Island provided an unusual opportunity for seeing hawks migrating against the wind -- south away from the open lake. Many individuals, particularly sharp-shinned, made progress by apparently flapping much more frequently than they had on their way north with a favorable wind. Some hawks seemed reluctant to turn about at the lakeshore, drifting a short way over the water before they would begin their struggle back. On windier days broad-winged hawks had difficulty reversing their flight direction. If they began at high altitudes, they could gradually drop on set wings, their momentum carrying them against the breeze. But soon they would have to circle and glide to regain altitude, and while soaring the wind would be blowing them north again. It was not unusual to see the same flock over the lighthouse several times.

Outer's south end offered another vantage point for hawk observations. Here migrants could be seen arriving on the island from the direction of Stockton Island to the southwest. At times some hawks were reaching Outer while others were flying in exactly the opposite direction off the island. These latter birds presumably had already traveled to Outer's north end and now were retracing their route.

This phenomenon occurred most strikingly at mid-day on May 8, 1976, when winds came out of the west at 10 to 13 MPH. Hawks in large numbers, including ten different species, were circling over South Pond and Outer's southern woodlands. Sharp-shinned hawks sped along the beach with wings beating furiously, forced by the wind to pass as low as ten feet over the ground. Where the passage to Stockton was shortest, these lone birds would take out over the water, barely clearing the wave tops.

The broad-winged hawks appeared hesitant to cross the water in such blustery weather. Frequently birds would hang over the beach edge then retreat over the forest, where I believe the trees broke the force of the wind. I counted 550 broad-winged in flight at once, scattered everywhere over the island as far north as I could see. Apparently migrants had been arriving at Outer through the morning, but the reverse flight south was stopped by wind and water. At last a flock of 132 set out over the lake, until the wind blew them southeast away from Stockton or any land, and they had great difficulty even regaining Outer. A lone rough-legged appeared to fare better.

Late that afternoon I hiked to the lighthouse. The following morning, May 9, large flocks of broad-winged were circling over the light. At 9:40 A.M., I counted 830 individuals in the sky. The flocks of the previous day, after spending the night on Outer, once more were drifting north with the wind, before they would turn about again and leave the island.

I have located only one report for the Great Lakes region of wind impact on hawk migrants similar to my May 8-9 sighting. Mueller and Berger (1965) reported that on the extraordinarily late date of 26 June 1960, between 300 and 1000 broad-winged were circling counterclockwise around Washington Island

(off Door Peninsula in Lake Michigan), held there by an 8 to 18 knot southwest wind.

Even with gentle breezes, almost all hawks appeared to return to Outer's sandy south tip before leaving the island to make their way back toward the mainland. Almost all took the shortest water crossing toward Stockton. Exceptions to this behavior were noted only on two days. On May 3, 1977, one merlin flew southeast against a 7 to 9 MPH wind, from Austad Bay straight toward the Michigan mainland. On May 6, 1977, several sharp-shinned hawks left Outer south toward Michigan Island rather than southwest toward Stockton. The wind blew 7 to 9 MPH from the west.

On Outer, an observer can get a more complete count of all hawks on the island at the tapering south end than at the 2-mile wide north end. But even in calm conditions, many hawks turn back at the shore, rather than heading directly over less than 3 miles of water to Stockton. Great care must be taken to avoid double counting hawks. In Table 3, I list the response of hawks to Outer's south shore, with headwinds (from anywhere out of the northwest and west through south and southeast) at 6 or less MPH. While some individuals of most species turned back from the lake, buteos appeared much more hesitant than other species to cross.

Raptors are quite sensitive to wind speed and direction at the south end. On May 1, 1977, 6 turkey vultures turned back from the lake when facing an 8 MPH wind from the west-northwest; but soon after, when the wind subsided to 4 to 6 MPH, they departed. On May 6, 1977, with an 8 to 10 MPH west wind, a flock of broad-wingeds flew down the south point several times, always returning up the point rather than crossing water. As soon as the wind shifted to the north-northeast, broad-wingeds started to leave.

Behavior of broad-winged and sharp-shinned hawks at the south end of Outer, in response to headwinds of differing strengths, is shown in Tables 4 and 5. Only observations taken with southerly or westerly winds (headwinds for hawks leaving Outer for Stockton) are included. With winds over 7 MPH, the great majority of broad-wingeds did not leave Outer, while most sharp-shinned continued to do so.

Between May 17 and 21, 1977, hawks were noted leaving northeast Stockton for Outer, and arriving on Stockton from Outer. Of the small sample of 44 observed, 3 left for Outer, 30 arrived from Outer, 10 turned away from the lake or followed the shore, and 1 flew slightly west of north, toward Cat Island. The disparity between numbers arriving and departing corresponds with the data on south Outer that suggests that the flight path off Outer is more concentrated than for north-bound birds, which may reach Outer from many points west and south. Raptors reaching Stockton from the lake appeared to continue straight over the forested interior, without showing a tendency to follow the shoreline.

On Presque Isle Peninsula at the southeast of Stockton, raptors were generally seen in only small numbers, and none were noted departing for islands to the south. But on two occasions flocks of broad-wingeds were noted traveling south over the beach at Presque Isle Bog. On May 23, about 20 were spotted by picnickers, on the day that Outer Island had its largest count of the season. On May 16, I counted 107 broad-wingeds during a

Table 3. Response of Raptors to South Outer's Shore, With Westerly or Southerly Winds at 6 or Less MPH.

<u>Species</u>	<u>Flying South</u>	<u>Flying North</u>	<u>Turning at Shore</u>
Turkey vulture	6	1	0
Sharp-shinned	129	8	25
Cooper's	1	0	1
Red-tailed	14	1	23
Red-shouldered	0	0	1
Broad-winged	242	4	204
Rough-legged	11	1	3
Bald eagle	1	0	0
Marsh harrier	5	1	1
Kestrel	3	1	0
Totals	412	17	258

*Winds measured at 4 to 6 feet above the ground.

Table 4. Behavior of Broad-winged Hawks on South Outer Island with Westerly and Southerly Winds of Differing Strengths*

<u>Wind Speed</u>	<u>Flying South Off Island</u>	<u>Flying North Onto Island</u>	<u>Turning at Shore</u>
0 - 2 MPH	204	2	169
3 - 6 MPH	38	2	35
7 - 10 MPH	16	0	109
11 - 15 MPH	0	0	1
Totals	258	4	314

*Winds measured at 4 to 6 feet above the ground.

Table 5. Behavior of Sharp-shinned Hawks on South Outer Island with Westerly and Southerly Winds of Differing Strengths*

<u>Wind Speed</u>	<u>Flying South Off Island</u>	<u>Flying North Onto Island</u>	<u>Turning at Shore</u>
0 - 2 MPH	70	4	5
3 - 6 MPH	59	4	20
7 - 10 MPH	111	27	25
11 - 15 MPH	0	0	0
16+ MPH	3	1	0
Totals	243	36	50

*Winds measured at 4 to 6 feet above the ground

1 1/2-hour watch. Seventy-seven traveled south, while 30 went north. Due to Stockton's size, lack of variety of topography and vegetation, and proximity to other islands in many directions, it appears unlikely that hawk flights as large as those on Outer can be observed with any frequency at a particular location.

On the west end of Michigan Island hawks were observed arriving from the north side of Madeline Island and continuing northeast, paralleling Michigan's north shore. The high count came on the unusually late date of June 2, with nearly 100 hawks, mostly broad-wingeds. A smaller number of hawks traveled in the opposite direction, toward Stockton, Hermit, and Madeline Islands.

Very few hawks were noted on Devil's Island. Most were in the interior. One sharp-shinned hawk left the north end heading northwest over the open lake. Two harriers, three sharp-shinneds, and one unidentified hawk turned back from the shore. Only one hawk was noted during the south end watches, a red-tailed leaving southeast toward Rocky Island. It appears likely that hawk flights here resemble those on Outer, although on a considerably smaller scale.

The Apostle Islands are not an ideal area for observing the magnitude and duration of spring hawk flights on Superior's south shore. Travel is difficult on and especially between islands. During early portions of the migration, movement by boat is impossible or unpredictable because of ice. Mainland look-outs at places like Keweenaw and Whitefish Point provide less difficulties for the observer.

However, the flights should greatly interest National Lakeshore visitors and for that reason warrant study. More importantly, the Apostle Islands group collectively offer superb opportunities for observing the responses of migrant raptors to water barriers of different widths.

Hawks leaving Outer Island have a long journey if they would avoid a lake crossing. They might pass around Superior's west tip, nearly 100 miles to the west. But with the common west and southwest winds, it appears likely they would often travel the other way, toward the Keweenaw Peninsula and the lake's east end 300 miles away. Observations of Wood (1933) at Keweenaw indicate that lake crossings from there are much more frequent than from the Apostles. Hawk behavior at Keweenaw's shore needs to be more precisely quantified, and an explanation sought for the differing response of raptors to the lake at the two locations.

Haugh (1972) states that some hawks travel for nearly 400 miles along the southeast shores of Lakes Erie and Ontario. This easterly flight direction does have a significant northerly component, unlike the situation at Superior, where the lake extends almost directly west to east. Mueller and Berger (1969) reported that in spring many hawks fly south past Cedar Grove, on the west shore of Lake Michigan. Three of these birds that they banded were retrapped in the same or the following breeding season in lower Michigan. These records suggest that some hawks, encountering Lake Michigan on its west side, may reverse their migration to travel far south around the south end of the lake before turning north again toward their nest grounds. The Great Lakes appear to have a massive effect on migrant raptors, causing displacement across hundreds of miles.

PASSERINE FLIGHTS -- RESULTS

As for hawks, most passerine data were collected on Outer Island and flights here will be discussed first. Woodpeckers and mourning doves are included in passerine totals in all analyses. Swallows have been excluded, because feeding flights were difficult to distinguish from migratory movements.

I compare numbers of birds sighted in 1976 at north and south ends of Outer in Table 6. The south end attracted greater concentrations. This difference was most striking during my half-hour observations of flight directions. Over thirty times as many migrants were seen in flight at the south end as at the north end. For Table 6, all bird species were considered, but passerines heavily dominated the totals.

Passerine flight observations for 1977 at Outer and Devil's Islands, the two northernmost Apostles visited, are summarized in Table 7. Consistent with 1976 results, volume of flight was much greater at Outer's south point than at either the lighthouse or Austad Bay.

✓ Data from the north end indicate that migrants do not heavily concentrate by the shoreline. Birds at two forested count stations at the very north end of the island were compared with two forested stations about 3/4 of a mile inland. The coastal stations averaged 6.7 species and 9.8 individuals on thirteen mornings, as compared with 5.0 species and 8.9 individuals at the interior stations. This slight tendency toward greater densities at the shore itself is far less significant than the effect of differences in habitat on north end counts, as will be discussed later in the section on beaver clearings.

Particularly in the morning, small numbers of day-flying passerine migrants were observed traveling north over the island's interior until the open lake confronted them. Responses of the migrants to the lake varied. Many immediately turned about and flew back south. Others landed in the northernmost trees of Outer, to rest briefly before flying south, or else east or west along the lakeshore. Very few actually set out over the lake.

Table 8 shows the behavior of all flying migrants noted during the 94 half-hour watches at the lighthouse meadow and at Austad Bay in 1976 and 1977. While 1,692 individuals turned at the shore, only 194 individuals flew north for a lake crossing. This strong tendency for northern movement

Table 6. Comparison of Bird Numbers at North and South Ends of Outer Island in 1976

	<u>North End</u>	<u>South End</u>
Total Species Observed Through Study Period	141	167
Average Species Total per Morning for 16 Count Stations*	31.4	42.3
Average Individuals Total per Morning for 16 Count Stations*	110.9	143.9
Average Individuals Total per 1/2-hour Watch of Flight Directions	14	443

* for nine mornings at each end of the island between May 15 and June 3, 1976.

Table 7. Summary of Passerine Flight Observations, Outer and Devil's Islands, 1977.

	<u>South Outer</u>	<u>North Outer (Light)</u>	<u>North Outer (Austad Bay)</u>	<u>South Devil's</u>	<u>North Devil's</u>
Number of Watches	131	54	32	42	21
Average number of birds sighted	208.6	23.0	13.7	12.7	7.6
Average number crossing lake	183.0	1.7	2.4	3.9	0.4
Average number turning at shore	18.4	20.8	11.2	7.4	7.0
Percent day- fliers	25.7	93.7	94.3	23.8	98.0
Percent night- fliers	49.9	2.7	0.9	68.9	2.0
Percent day- fliers turning	16.1	92.4	81.1	63.8	91.6
Percent night- fliers turning	7.1	86.5	100.0	55.4	100.0
Percent day- fliers crossing	74.5	7.6	18.9	16.5	5.4
Percent night- fliers crossing	91.6	3.1	0.0	32.3	0.0
Percent day-fliers reaching island from south	9.4	--	--	--	17.3
Percent night- fliers reaching island from south	1.3	--	--	--	2.0
Total species crossing	50	6	3	13	3
Total species sighted	55	23	10	20	14

Table 8. Passerine Behavior on North Outer, 1976 and 1977

<u>Species</u>	<u>Lighthouse</u>		<u>Austad Bay</u>		<u>Total</u>	
	<u>Stopped</u>	<u>Crossing</u>	<u>Stopped</u>	<u>Crossing</u>	<u>Sighted</u>	<u>% Crossing</u>
Eastern kingbird	6	0	0	0	6	0.0
Blue jay	715	66	108	0	889	7.4
Raven	2	0	1	0	3	0.0
Common crow	10	0	20	0	30	0.0
Black-capped chickadee	0	0	40	0	40	0.0
Robin	25	0	6	0	31	0.0
Cedar waxwing	9	0	0	0	9	0.0
Starling	40	5	1	0	46	10.9
Palm warbler	4	0	1	0	5	0.0
Warbler sp.	20	0	3	0	23	0.0
Red-winged blackbird	60	1	17	17	95	18.9
Common grackle	82	10	3	3	98	13.3
Brown-headed cowbird	233	18	106	53	410	17.3
Blackbird sp	42	0	32	5	79	6.3
Pine siskin	2	15	0	0	17	88.2
American goldfinch	45	0	0	0	45	0.0
Misc. night migrants	17	1	0	0	18	5.6
Passerine sp.	21	0	21	0	42	0.0
Totals	1333	116	359	78	1886	10.3
% crossing	--	8.1	--	17.8	--	--

to halt also typified our general observations throughout both seasons on north Outer. While we saw many hundreds of migrants turn about at the shore (Appendix A lists the 44 species identified, including non-passerines as well as passerines), only 14 species (8 of these passerine) actually set out across the lake.

When lake crossings were initiated, the Minnesota (north) shore of Superior was often but not always visible. A few birds even flew out into a thick fog bank. In 1977, all crossings had following (southerly) winds or nearly calm conditions. Four times in 1976, migrants went north from Outer against northerly winds 5 to 9 MPH. As with hawks, some of the passerines recorded as north-flying probably turned far out from shore and came back to Outer. Flocks often were noted changing direction, sometimes frequently, over the water; a few other flocks abandoned their attempt to cross. On one occasion, I saw two crows fly east from Austad Bay until they joined eleven other crows not previously seen, far out over the water. The scattered group flew in several directions before returning to Outer. This observation confirms that some migrants even as large as crows reach Outer's north end at altitudes high enough to make initial detection unlikely.

In Figure 6 are listed the frequency for lake crossings from north Outer at different times of day, for passerines and for hawks. Times were calculated in relation to dawn, as daylight rather than Central Daylight Time affects migrant behavior. Times for dawn were obtained using tables of the Royal Astronomical Society of Canada (1976, 1977). During the study, dawn came as late as 5:54 A.M. CDT in late April to as early as 5:09 A.M. CDT in early June. Over $\frac{3}{4}$ of the passerine sightings occurred during the first two hours after dawn. All movement north ended by mid-morning. North-bound raptors, in contrast, were not particularly evident in the early morning hours, but were noted throughout the day until mid-afternoon.

Migrant behavior was rather similar at the lighthouse and at Austad Bay. As migrants could be seen flying in both directions along the shore at both locations, it appears probable that passerine behavior does not vary significantly anywhere along Outer's two-mile wide north end. However, at Outer's northeast corner, where the land extends out in several short points, a higher percentage of migrants sighted flew north from the island than at the lighthouse (see Table 8). And on four occasions blackbird flocks flew northeast from Austad, but then veered right and disappeared far to the southeast, toward the Michigan mainland over 30 miles away.

The north end of Outer is forested, offering very limited areas of open ground for hunting by kestrels. One dawn at Austad Bay, a kestrel flew out over the lake, and returned with a freshly caught passerine. The following dawn, a kestrel -- perhaps the same bird -- twice flew out over the lake. Both times it turned about high over the water, and pursued small birds barely visible even in binoculars. On both occasions it easily caught its bird. The passerines' evasive attempts seemed feeble. One managed to dodge the kestrel's talons as the falcon came from behind; but immediately after, the kestrel, upside down in the air, reached up and grasped its prey.

That morning the sky had a high overcast. By lying flat on my back and looking directly up I could detect, sometimes only with binoculars,

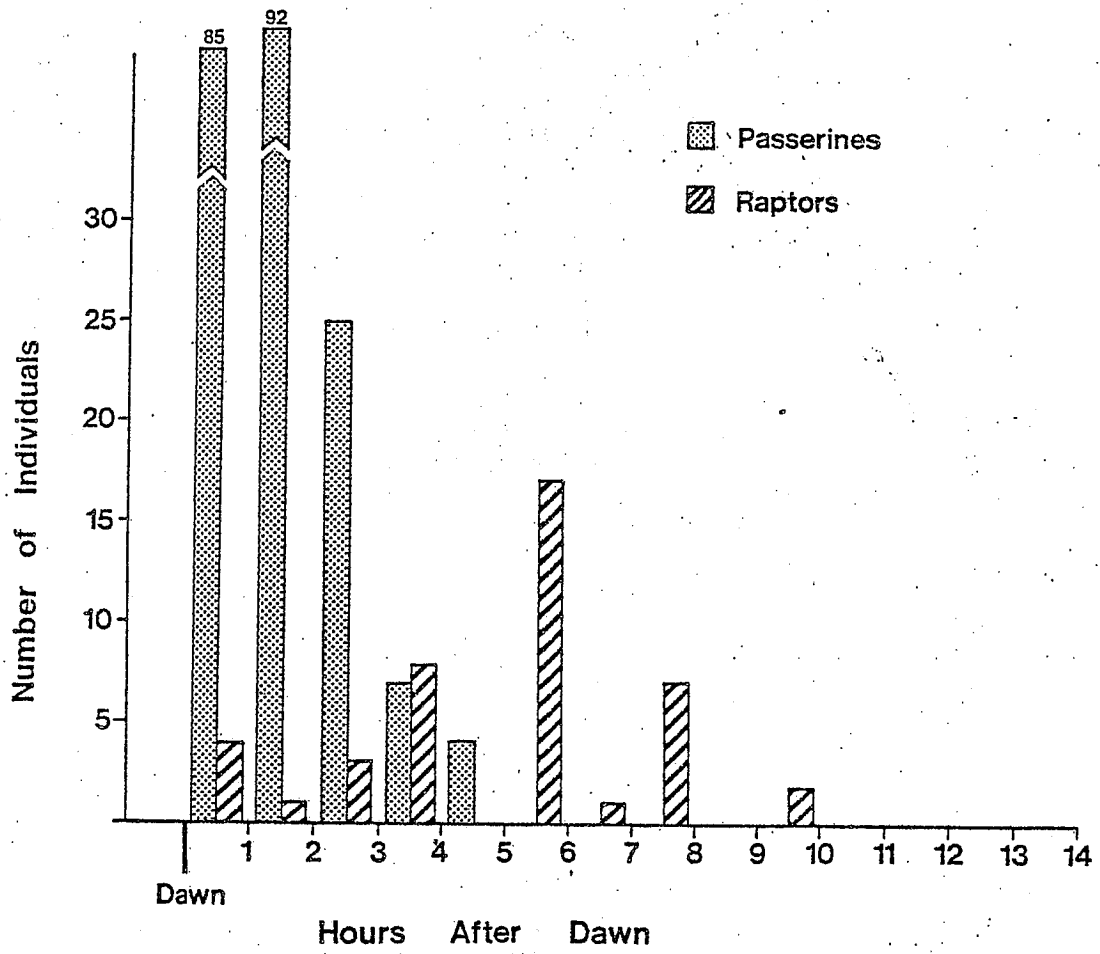


Figure 6. Time of Day for Lake Crossings from North Outer, 1977.

very high passerines flying southwest from off the lake over Outer Island. They were so hard to see I could form no idea about how many were thus arriving from the open lake. They were small and several uttered warbler call notes, indicating that these were night-flying migrants that had gone out over Superior before dawn, and were now regaining land in the early light. At this time, far from cover and weary from a long migratory flight, they were easy prey.

We noted similarly high, south-bound birds on a later day. But without clouds and calm conditions, these birds would probably be impossible to detect.

Events at south Outer help to clarify the situation on north Outer. In Table 9, passerines in flight at south Outer are tabulated according to groups of species and behavior. Birds flying south comprised 87.7% of all birds observed, with only 3.5% flying north onto Outer and 8.8% turning back at the shore. Hawk data (see Table 3) revealed a much higher proportion turning away from the water. During the entire two-season study, a total of 68 species (passerine and non-passerine) were identified flying off Outer toward Stockton Island -- they are listed in Appendix B.

In Table 9, subtotals were calculated for all birds primarily migrating by night and for all birds migrating primarily by day. For this, I relied on a listing of day and night migrants made by Brewster (1886). In the few cases where Brewster did not clearly place a species in either category, I followed reports in the literature and my own observations. It should be noted that some individuals of some night-flying species will travel by day, while some typically day-fliers will move at night. In the early morning, when most south Outer counts were taken, both groups moved in sizable numbers. Those passerines not identified were placed in a third, general category.

At south Outer, night-fliers outnumbered day-fliers by more than 2 to 1. Percentages of day-fliers actually traveling south off Outer were less than for night-fliers.

Volume of southward flight at Sand Point for varying times of day is indicated in Figure 7. Numbers of birds sighted were averaged for all watches whose mid-points occurred during each half-hour interval after dawn. Numbers of night migrants peaked in the second and third half-hour periods after sunrise, while volume of day migrants generally was highest from the second through the seventh half-hour periods. Migrant activity was slight before dawn or past 6 hours after dawn. The limited duration of flight by day migrants is noteworthy. Evans' (1966) radar and visual observations in Northumberland indicated that the decline in numbers of skylarks (a day migrant) after early morning was due to an early cessation of migration rather than a rise of migrants to altitudes too high for detection by human eyes.

Changes in numbers of all migrants closely approximated changes in numbers of night migrants. This resulted in part because of the large proportion of night migrants present, and in part because most unidentified birds were probably the difficult-to-distinguish warblers, sparrow, thrushes, and flycatchers, all night migrants.

Table 9. Behavior of Passerines in Flight, South Outer, 1977

<u>Species</u>	<u>Flying South</u>	<u>% Flying South</u>	<u>Flying North</u>	<u>% Flying North</u>	<u>Turning at Shore</u>	<u>% Turning at Shore</u>	<u>Total</u>
Passerine sp.	6,246	93.7	113	1.7	304	4.6	6,663
Woodpeckers	113	68.5	30	18.2	22	13.3	165
Night thrushes	30	90.1	0	0.0	3	9.1	33
Warblers sp.	5,720	91.9	46	0.7	455	7.3	6,221
Night-flying sparrows and finches	1,897	94.9	35	1.8	66	3.3	1,998
Misc. night-fliers	4,741	90.6	63	1.2	429	8.1	5,233
Subtotal -- night-fliers	12,501	91.6	174	1.3	975	7.1	13,650
Corvids	1,832	74.6	60	2.4	563	22.9	2,455
Robin and bluebird	143	44.1	87	26.9	94	29.0	324
Starling and blackbirds	3,033	78.0	499	12.8	358	9.2	3,890
Day-flying finches	41	75.9	7	13.0	6	11.1	54
Misc. day-fliers	177	60.0	4	1.4	114	38.6	295
Subtotal -- day-fliers	5,226	74.5	657	9.4	1,135	16.2	7,018
Total passerines	23,973	87.7	944	3.5	2,414	8.8	27,331

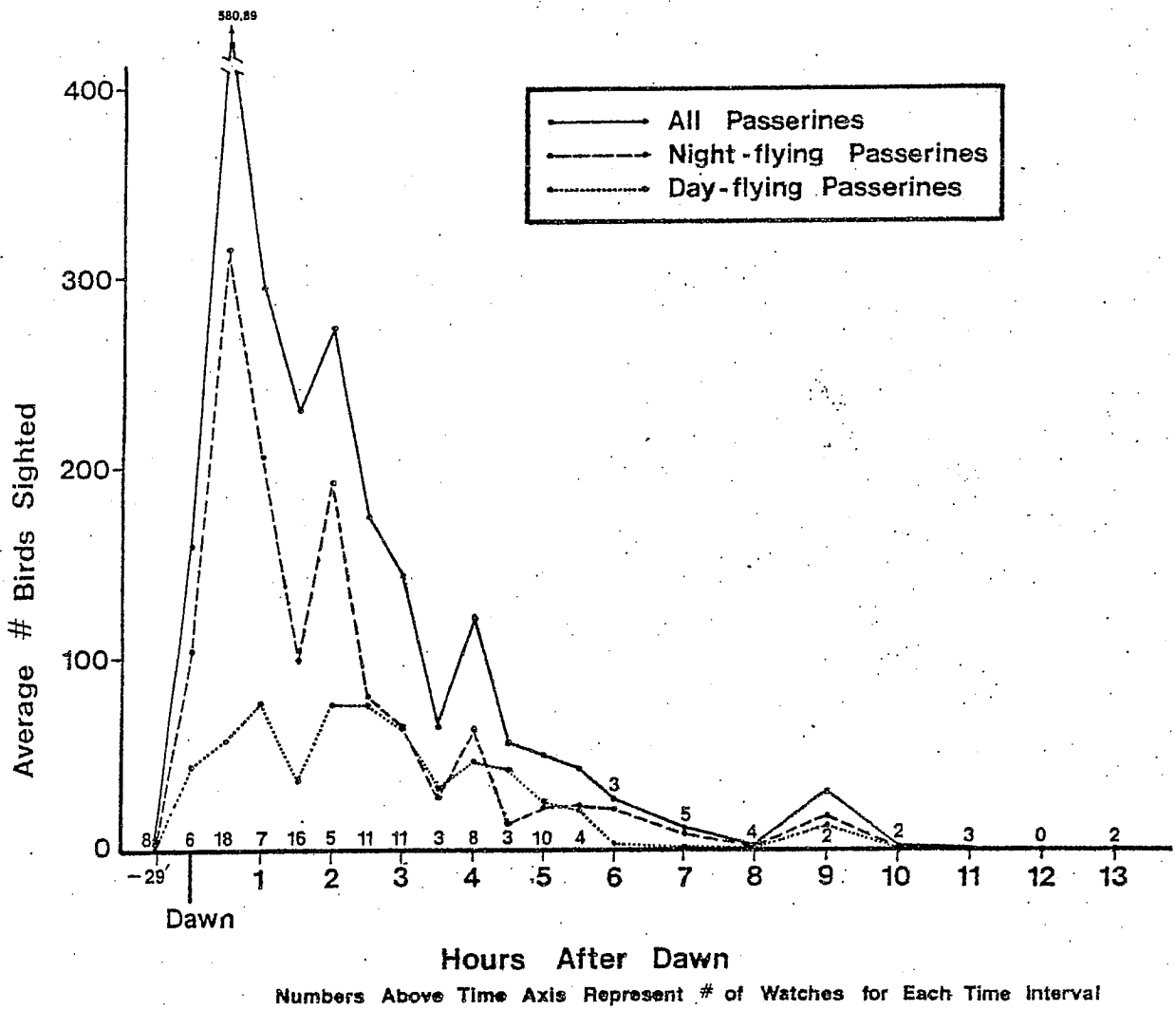


Figure 7. Volume of Southward Passerine Flight Through the Day at South Outer, 1977.

Volume of passerine flight at the lighthouse and Austad Bay for varying times of day is presented in Figure 8. Volume is drastically smaller than at the south end except before dawn and in the late afternoon. Changes in volume at the two ends of Outer are similar, except that at the north end hourly averages drop off more rapidly past 4 hours after dawn.

Average numbers of day and night migrants sighted per watch at south Outer during each time interval and percentages of birds flying north, south, or turning at the south shore are listed in Table 10. Day migrants outnumbered night migrants only in the half hour before dawn and during most of the watches 2 1/2 hours and more after dawn. For almost every time interval, percentages of day-fliers were greater than of night-fliers for northward flight and for turning at the shore. These behaviors were particularly prevalent for day-fliers before dawn.

Commonest species identified in the south Outer flights are listed in Table 11. Totals are biased in favor of species easily recognized in flight. Yellow-rumped, palm, and probably other warblers were much commoner than indicated here. The nuthatches were primarily red-breasted, with a few white-breasted. The percent of each species turning away from the lakeshore provides a measure of reluctance to cross water, at least in a southerly direction. The majority of chickadees and nuthatches turned about. Blue jays, robins, and cedar waxwings also were particularly deterred by the lake. The two warblers reacted with least frequency.

Peak flight times were calculated for eight species. The three night migrants reached their peaks earlier in the morning than any of the day migrants.

The species composition of these reverse (southward) flights contrasts with the situation at the same time of day on north Outer. Almost all birds sighted at the north end and listed in Table 8 were day-flying migrants (see Brewster, 1886). The main exceptions were the very high-flying passerines seen coming off Superior. But at the south end, flights consisted primarily of warblers, sparrows, thrushes, and kinglets, all night migrants.

The reverse flight was perhaps most spectacular on the morning of May 13, 1976, when the sky was overcast and the light south-southeast breeze carried a drizzle. The southern woodlands held many thousands of warblers and kinglets. Very few were feeding. Most were in constant motion, passing from one tree to the next and on down the island. The ground held throngs of sparrows and juncos, and these flocks also kept restlessly flurrying south. I noted 84 bird species in five hours.

The migrants converged on Outer's south tip, their call notes filling the air with sound. Between 0800 and 0830 I counted 2,338 birds departing for Stockton.

On all mornings birds appeared to leave south Outer for Stockton from the sand tip, where the water crossing is shortest. Sometimes the south-bound flocks moved from tree to tree, as on May 13, while on other days many migrants traveled at greater heights and did not pause. On a couple of days we detected high-flying passerines here with binoculars that we did not include in the totals of lower migrants easily visible without binoculars.

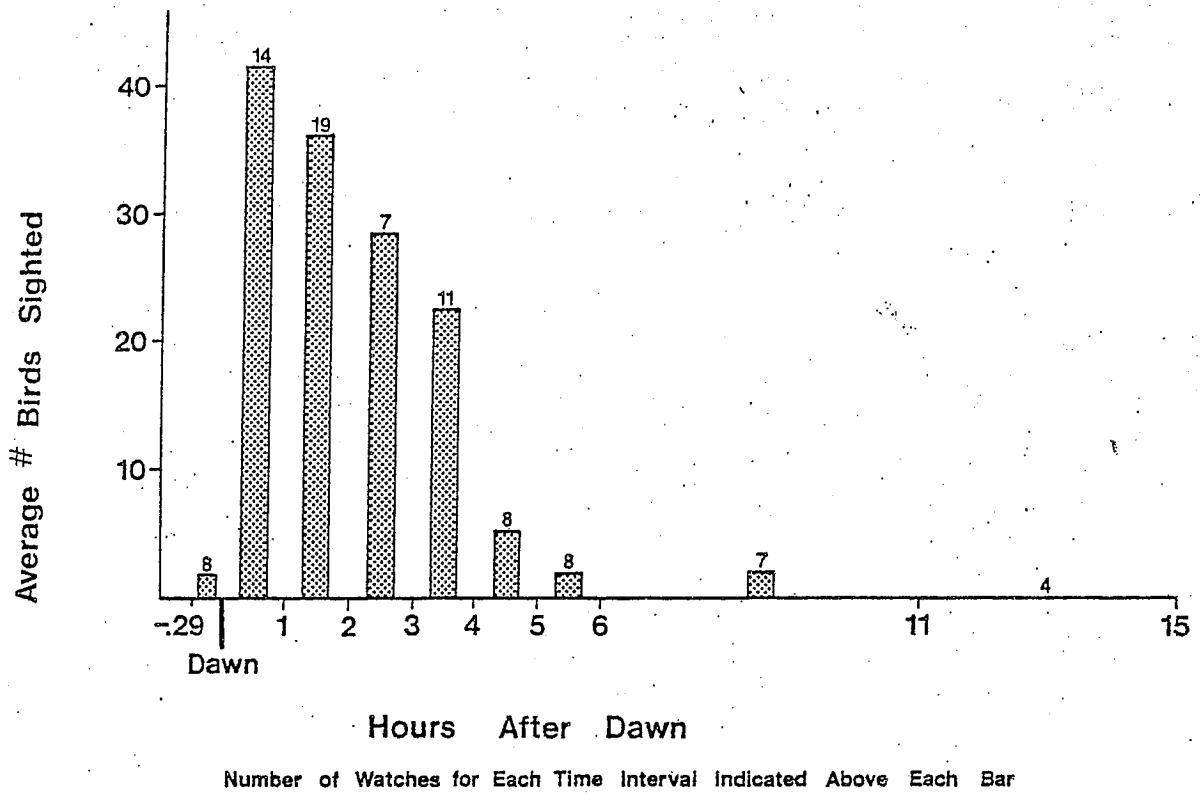


Figure 8. Volume of Passerine Flight Through the Day at North Outer, 1977.

Table 10. Behavior of Day and Night Passerine Migrants at South Outer, 1977

Time in hours and minutes after dawn	-----Night-fliers-----				-----Day-fliers-----			
	Average number sighted per watch	% Flying North	% Flying South	% Turning at Shore	Average number sighted per watch	% Flying North	% Flying South	% Turning at Shore
-0.29 - 0.00	2.3	0	94	6	7.8	29	40	31
0.01 - 0.30	112.8	1	92	7	58.2	7	70	22
0.31 - 1.00	314.8	0	95	5	81.9	16	69	16
1.01 - 1.30	228.3	1	91	8	100.9	2	76	21
1.31 - 2.00	103.1	1	90	9	45.2	15	75	10
2.01 - 2.30	207.8	0	91	9	85.8	7	87	6
2.31 - 3.00	94.4	4	84	12	99.5	3	76	21
3.01 - 3.30	72.6	1	91	8	86.7	7	76	17
3.31 - 4.00	33.7	1	79	20	53.3	5	58	37
4.01 - 4.30	70.6	2	92	7	60.1	5	76	19
4.31 - 5.00	17.3	4	77	19	72.7	1	52	47
5.01 - 5.30	24.7	4	80	16	29.9	11	76	13
5.31 - 6.00	20.5	6	90	4	25.5	2	70	28
6.01 - 7.00	23.0	6	84	10	4.3	23	54	23
7.01 - 8.00	8.8	2	84	14	2.0	10	80	10

Table 10. Continued

Time in hours and minutes after dawn	-----Night-fliers-----				-----Day-fliers-----			
	Average number sighted per watch	% Flying North	% Flying South	% Turning at Shore	Average number sighted per watch	% Flying North	% Flying South	% Turning at Shore
8.01 - 9.00	2.0	0	75	25	1.3	0	100	0
9.01 -10.00	12.5	4	96	0	17.0	0	100	0
10.01 -11.00	1.0	100	0	0	1.0	0	100	0
11.01 -12.00	0.0	--	--	--	4.0	0	0	100
12.01 -13.00	--	--	--	--	--	--	--	--
13.01 -14.00	0.0	--	--	--	0.0	--	--	--

Table 11. Commonest Species Identified in Flight at South Outer Island, 1977

Species	Total Observed	# Flying South	% Flying South	# Flying North	% Flying North	Number Turning	% Turning	Peak Period of Flight ¹	Peak time of day ²
Blue jay	2,339	1,771	75.7	33	1.4	535	22.9	May 13 - 19	+2.05
Brown-headed cowbird	1,781	1,403	78.8	282	15.8	96	5.3	April 29 - May 11	+1.50
Starling	629	546	86.8	18	2.9	65	10.3	29 April - May 13	+1.45
Yellow-rumped warbler	422	407	96.4	6	1.4	9	2.1	April 29 - May 12	+1.32
Red-winged blackbird	407	319	78.4	65	16.0	23	5.7	April 30 - June 3	+2.36
Rose-breasted grosbeak	331	298	90.0	2	0.6	31	9.4	May 12 - 24	+1.22
Robin	319	138	43.3	87	27.3	94	29.5	April 29 - May 17	--
Common grackle	208	150	72.1	25	12.0	33	15.9	May 1 - 24	+3.13
Common flicker	149	102	68.5	29	19.5	18	12.1	April 29 - May 1	+1.31
Cedar waxwing	142	107	75.4	0	0.0	35	24.6	May 13 - 28	x
Black-capped chickadee	108	40	37.0	0	0.0	68	63.0	x	x
Palm warbler	108	103	95.4	0	0.0	5	4.6	May 10 - 14	x
Common crow	98	58	59.2	25	25.5	15	15.3	x	x
Nuthatch sp.	42	20	47.6	0	0.0	22	52.4	x	x

¹ peak period ranges from the first to the last of the 5 days with highest 1/2 hour watch totals for that species
² peak times are average of midpoints of all watches, with highest total for that species on each day on which species recorded on 3 or more watches
 x insufficient data

Of all birds seen at Sand Point, only 9 -- 2 flickers and 7 thrushes -- set out west toward Cat and Oak Islands.

We ran several series of concurrent watches to obtain comparisons of volume of flight at different parts of south Outer. An old railroad cut crosses the forest west to east about 3/5 mile north of the south tip, 1/5 mile north of the primary watch location at the base of Sand Point. Seven pairs of concurrent watches were recorded on six mornings at east and west ends of the railroad. The west side counts of south-bound birds were greater 6 out of 7 times, averaging 242 birds per watch, as compared with 149 on the east side. However, north-bound counts were greater on the east 5 times, averaging 46 birds per watch as compared with 18 birds on the west side.

Seven additional concurrent pairs of watches were recorded on two days, from the west side of the railroad and from a point on the east shore 4/5 of a mile north of the south tip. On all 7 watches, both south-bound and north-bound counts were greater at the west side. The difference was greater for south-flying birds (averages of 39 and 6) than for north-flying migrants (averages of 7 and 1).

The data indicate that more migrants approach the south tip of Outer down the island's west side than the east side. The great majority of birds sighted at the west end of the railroad flew over the forest edge rather than the wide beach. Birds flying north from the south tip (whether flying toward north Outer or turning away from the water crossing) initially concentrate along the east edge of the forest, although the effect soon vanishes with increasing distance up the island.

Twelve pairs of concurrent watches on three days were compared from the base of Sand Point and from near the west shore of Outer at the north end of South Pond, 1 4/5 miles north of the south tip. South-bound counts and north-bound counts (including birds that turned at the south shore) averaged 203.3 and 38.8 per watch, respectively, at Sand Point, as compared with 41.0 and 3.1 for the north end of South Pond. On none of the watches did migrants appear concentrated along the west shore at this distance from Sand Point. Our general observations on south Outer suggest that most birds turning back from the south shore do not travel north past South Pond.

Even at south Outer, data were not collected on a sufficient number of days to allow meaningful correlations between various weather factors and volume of passerine flight. Even if more extensive data had been taken, conclusions could pertain only to those birds flying low enough to be visible from the ground. With the data available, I have only undertaken tentative analysis of the effects of wind direction. Out of the seven mornings in 1976 and 1977 with the highest peak, single watch totals, on five I recorded winds from a southerly direction (west-southwest to east-southeast) at 4 to 6 feet above ground level. Of the seven mornings in 1977 with lowest peak, single watch totals, only one had southerly winds. Low flight days were not included from 1976, because the only watches held each day that year were often before dawn, when flight totals almost always are small.

Southerly winds opposed the reverse migration from south Outer but favored northward progress of the same migrants before they encountered the

open Lake Superior and turned back toward the inner islands. Southerly winds have been positively correlated with northward spring passerine migration in many studies. I would expect size of the reverse flights to show highly positive correlations with size of the northward flight of the same morning (for day-flying migrants) and the previous night (for night-flying birds), and thus also with weather conditions favoring large northward movements. Therefore, large passerine flights are likely to occur on days after passage of a high pressure system and/or before the arrival of a low pressure system, as Curtis (1969) documented for migration at Madison, Wisconsin, and Richardson (1971) demonstrated for southern Ontario.

Passerine flights were observed on northeast Stockton for 5 days, from May 17 to 21, 1977. Twelve pairs of watches on three days at the height of migration were recorded concurrently on northeast Stockton and south Outer. Results are presented in Table 12. On Stockton, passerines could be seen both arriving and departing. Totals for the two locations were roughly comparable except for south-bound birds, where the flight observed at Outer was dramatically larger.

However, many of those flying south at Stockton were recorded at high altitudes only with use of binoculars during cloudy weather. Many others probably escaped detection. South-flying passerines did not appear to alter their flight direction as they left the lake to cross Stockton's interior; I did not find them concentrated at any part of Stockton's blunt northeast shore.

South-bound birds included both day- and night-fliers. Only day-fliers (the great majority blue jays) were recorded traveling north. Three passerines flew toward Cat Island rather than Outer.

Nowhere on southeast Stockton did counts approach the tallies for south Outer. Over all, an average of 15.9 passerines were sighted per watch, almost all day-fliers. At Presque Isle Bog and at the pier, both away from Presque Isle Point's end, most birds flew south, with a few others heading north. Counts were 16.4 south-bound and 2.7 north-bound at the bog, and, at the pier, 4.6 south-bound and 2.0 north-bound. Some of the north-bound birds, at least at the pier, were probably retreating from the water crossing to the south. At the pier, 1 cowbird flew southwest straight toward Madeline Island.

Counts were also taken at the southeast and the south sides of the blunt end of the point. On the southeast, an average of 11.4 birds followed or turned from the shore, while 1.1 crossed the lake to or from Michigan Island. On the south of Presque Isle Point, a larger portion crossed the water -- 10.2 birds as compared with 12.4 turning or following the shore. At this site, 1 red-winged blackbird flew south, headed to the west of Michigan Island, as if toward the mainland beyond. None left toward Madeline, only slightly farther away than Michigan Island.

Passerine flights at the west end of Michigan were very light, even on mornings when over 200 birds were counted in single watches on south Outer. The few birds observed in late May and early June were traveling between Michigan and the east end of Madeline. In addition, one flock of 40 jays flew southeast toward the mainland, while on another day 10 passerines in a flock flew northwest toward Stockton.

Table 12. Passerine Flights on Northeast Stockton and South Outer Islands*

	<u>Northeast Stockton</u>	<u>South Outer</u>
Average number of birds per watch	45.0	608.6
Average number flying northeast	8.3	7.6
Average number flying southwest	6.0	580.4
Average number turning away from lake**	30.7	20.6

* Based on 12 pairs of concurrent watches on May 17, 19 and 20, 1977

** On Stockton, this figure included birds following shore.

Data on passerine flights at the north and south ends of Devil's Island are presented in Table 7. With two important exceptions, flights on Devil's generally parallel flights on Outer. But fewer birds were sighted at Devil's, particularly at the south end. Also, a larger portion of birds at south Devil's than at south Outer turned back from the lake rather than flying south toward the inner islands. These differences between the south ends of the two islands appear more clearly in Table 13, where 11 pairs of concurrent watches are compared.

The greater tendency for migrants to turn back from the south shore on Devil's appears due neither to the width of the water crossing (which is shorter at Devil's) or to the size of the flights (even with small flights on Outer, most birds continued south). Perhaps Outer's south tip leads birds out over the lake, while Devil's blunt end does not.

From south Devil's migrants departed for three inner islands. During the 42 watches, 60 birds flew southwest toward Bear Island, 55 flew southeast toward Rocky Island, and 27 flew south toward more distant Otter Island.

Peak times of flight on Devil's are similar to times on Outer. Peak times were calculated for each end of Devil's by averaging times of the mid-points of each watch that had the highest count for the day, for all flight days on which 5 or more watches were recorded. Average peak time on south Devil's was 43 minutes after dawn (for 4 days); at north Devil's, average peak was at 51 minutes after dawn (for 3 days).

Table 13. Passerine Flights on South Devil's and South Outer Islands*

	<u>South Devil's</u>	<u>South Outer</u>
Average number of birds per watch	16.6	112.9
Average number flying north	1.2	1.5
Average number flying south	6.4	88.3
Average number turning away from lake	9.0	23.1

*Based on 11 pairs of concurrent watches on May 27 and 28 and June 2 and 3, 1977.

PASSERINE FLIGHTS -- DISCUSSION

In Figure 9, I indicate the direction and magnitude of observed movements of night-flying and day-flying passerines in the eastern Apostles. The most remarkable feature of passerine migration through the Apostles is the large reverse migration off the northern islands, evident even against strong southerly winds.

Reverse migrations have been noted in many parts of the world. Recent radar studies have shown that many migrants will tend to travel with the wind, regardless of wind direction. Flights regularly occur even with winds in the seasonally inappropriate direction, although these movements are much smaller than flights where winds favor normal progress of migrants (Gauthreaux and Able, 1970; Richardson, 1971, 1972; Able, 1973).

Visual studies have also often recorded reverse migration. In Europe, north-bound migrants in spring have been observed retreating south during sudden cold weather (Svårdson, 1953); similar flights have been recorded in North America (Speirs, 1956; Drury and Keith, 1962). On the Atlantic coast in fall, northwest winds frequently blow night-flying migrants off their normal flight paths into coastal areas and offshore islands. By day these vagrants will fight the winds as they fly north to regain their customary migration routes (Allen and Peterson, 1936; Baird and Nisbet, 1960). At Point Pelee, reverse migrations frequently occur in spring. Pettingill (1964) speculated that the birds involved may have overshot their breeding grounds during the night and by day make their way back south. However, many of the birds reported flying south by Lewis (1939) do not nest south of Lake Erie. Gunn (1948) observed that the flights serve to disperse migrant concentrations at Pelee, a small area with a limited food supply.

Rabø1 (1969) documented an unusual instance of reverse flight as an explanation for the appearance of 4 species of Phylloscopus warblers in Britain, far out of their normal range. An occasional immature bird, rather than initiating its first migration in the normal easterly direction, apparently traveled in exactly the wrong way, due west.

Able (1972) noted that in coastal Louisiana in fall birds fly south only with a following wind. If they encounter adverse winds a short way offshore, they will reverse direction and return to land.

None of these situations bears close resemblance to events in the Apostles. However, Hebrard (1972) reported a high altitude northward flight

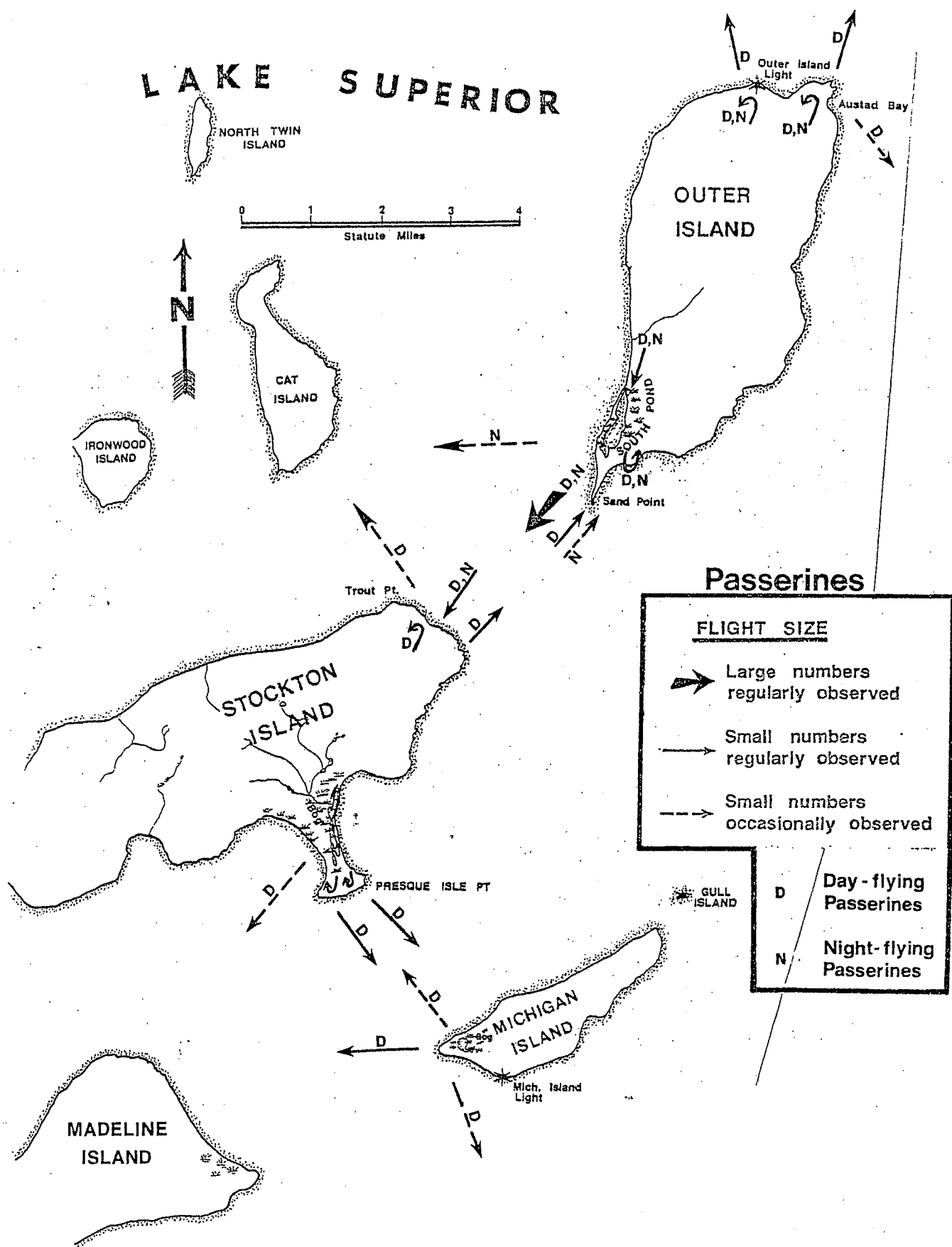


Figure 9. Patterns of Observed Passerine Migration - Outer, Stockton and Michigan Islands.

of migrants in fall on the Gulf coast, that appears quite similar to my observations on Outer. He discovered the movement at dawn on an overcast day, only with the use of binoculars. About 10% of the birds dropped down and landed in the woods at the coast. The rest continued inland. Hebrard speculated that this flight might have been an effort to regain land by birds migrating at night and finding themselves over water at first light.

Night-flying migrants do not deviate from their course at coastlines (Lack, 1959; Richardson, 1971). Large numbers of birds do cross Lake Superior at night, for Perkins (1964) discovered them from boats upon the open lake. In fall, the Apostles receive heavy flights of night migrants, which would not appear if the birds did not readily cross the lake. In a half-hour period on September 28, 1976, I counted 1,456 passerines leaving the west end of Michigan Island west toward Madeline Island.

In spring, the pre-dawn light, which reveals the lake, also signals the approaching end of that particular flight period for night migrants. Passerines then are reluctant to begin or complete the long water crossing. Turning about and still at relatively high altitudes, they do not concentrate at the north edge of the Apostles, instead continuing through the island interiors and on to the inner islands. I do not know if they continue in order to disperse over a large area of habitat, or whether their urge for movement is too strong to allow them to pause.

At this time, day migrants begin their journeys. Most of them low enough to be visible turn back at the northern shore of the northern islands (radar would reveal whether birds at greater heights fly on north). Day migrants, therefore, tend to reach south Outer a little later than do the night migrants. Especially in the early hours, at the beginning of their flight period, they appear to be less willing to cross water south off Outer than are the night migrants.

While many migrants leave south Outer at low heights, by the time they reach Stockton they are too high to be readily observed even with binoculars. A similar ascension of birds over water has been noted at Nantucket Island (Baird and Nisbet, 1960). On Stockton, migrants disperse widely. While some, at least, of the day migrants continue on toward islands to the south, significant numbers of them are not visible from any one site. The shapes of the inner islands and the nearby mainland, and their relation to one another, do not seem to favor migrant concentrations, at least in spring. Events on northeast Stockton suggest that small numbers of day migrants can probably be seen on most of the islands' north shores, hesitating before leaving land.

The difference in size of passerine counts at south Devil's and south Outer (see Table 13) is roughly proportional to the difference in widths of the north ends of the two islands, where night flying birds would arrive from the open lake before funneling south. This suggests that volume of flight on the northern Apostles or on peninsulas or islands anywhere along the south edge of Lake Superior would reflect the width of that piece of land. The number of passerines visible in spring at any one spot would depend on the extent to which the land form narrows to the south, along the path of the birds as they leave the lake. Outer, because of both its size and shape, appears to be the best observation point for passerines in the Apostles. Other sites with lesser concentrations might include the south ends of Devil's, Rocky, North Twin, Cat, Madeline, and York Islands.

The scarcity of hawks on Devil's when many raptors were present on Outer and Michigan Islands, and the occurrence of the largest hawk flights only with west or southwest winds suggests that, unlike for passerines, the eastern Apostles receive much larger hawk concentrations than the western. But it is possible, instead, that with southeast winds most hawks appear in the northwest Apostles. More data, taken concurrently from several points in the Apostles, would help to confirm one or the other hypothesis.

OTHER MIGRANTS

The open Lake Superior provides both a resting and a feeding area for very few species of birds -- only loons, horned grebes, double-crested cormorants, gulls, and some of the diving ducks. For all other species, the lake is a vast expanse to be crossed or avoided, or, in the case of terns, to be visited for fish.

During the two seasons, we sighted 22 species of shorebirds -- sandpipers, plovers, and their relatives. Except for woodcock and snipe, they were restricted to the Apostle's shore areas and the adjacent bogs. On Outer Island, the sandy south tip provided the only significant habitat. The treeless Sand Point extends for a half-mile into the lake, its beaches edged with some gravel, its central dunes sparsely covered with grasses. The wide west beach, reaching over a mile up Outer's west coast, and open edges of South Pond, also at times attract shorebirds.

In Table 14 I list the shorebirds counted in 1976 on Sand Point only. Most species did not arrive until late spring. The beaches drew small numbers but a rather interesting variety. Some individuals, such as the knot and two winter-plumaged sanderlings, remained at least four days.

The wide sand beaches at the west end of Michigan Island and on the east side of Presque Isle Bog on Stockton Island also attracted shorebirds, most notably whimbrel, recorded at both locations, and willet, on Stockton. Shorebirds on Stockton also used muddy islands in the bog, exposed because of the low water levels.

Outer Island contains limited habitat for birds of marshes and small ponds. However, at various times blue-winged and green-winged teal, black and mallard ducks all were seen in quick flight along the north shore of Outer, as if discouraged by Superior in their northward passage and seeking a resting place. Similarly, six double-crested cormorants flying northwest altered their course at the north island shore to vanish west toward North Twin Island. Great blue herons, black-crowned night herons, and sandhill cranes all were observed flying south away from the north shore.

Similar observations were made on Devil's Island, and a bittern was flushed several times from small pools within the interior forest.

The significance of beaver clearings for water birds is discussed in the next section. But on Outer Island, South Pond is by far the largest interior wetland, and contains the only vegetation suitable for bitterns

Table 14. Shorebird Counts at Outer's South Tip, 1976

<u>Species</u>	<u>May</u> <u>14</u>	<u>May</u> <u>21</u>	<u>May</u> <u>25</u>	<u>May</u> <u>26</u>	<u>May</u> <u>27</u>	<u>May</u> <u>28</u>	<u>June</u> <u>1</u>	<u>June</u> <u>2</u>
Semipalmated plover	--	--	--	1	--	--	1	1
Killdeer	*	*	*	*	*	*	*	*
Golden plover	--	--	--	--	1	1	1	1
Black-bellied plover	--	--	2	1	1	3	--	--
Ruddy turnstone	--	--	7	6	6	21	6	3
Whimbrel	--	--	7	--	--	--	--	--
Spotted sandpiper	*	*	*	*	*	*	*	*
Lesser yellowlegs	--	--	3	--	--	--	--	--
Knot	--	--	1	1	1	1	--	--
Least sandpiper	1	--	3	--	3	6	--	--
Dunlin	--	10	8	10	5	8	8	1
Semipalmated sandpiper	--	--	1	--	1	2	--	1
Sanderling	--	2	--	2	2	4	3	3
Totals:								
Species	3	4	10	8	10	10	7	8
Individuals*	1	12	32	21	20	46	19	10

* Killdeer and spotted sandpiper were present on all counts and are included in the species totals, but not in the individual totals.

and rails. The open waters of South Pond at one time or another sheltered 10 species of ducks as well as coots and pied-billed grebes. But all species appeared in very small numbers and none remained more than a day or two.

Before the 1976 season, I had predicted that South Pond would shelter sizable numbers of marsh birds, being the only suitable habitat for miles. However, I detected only one sora, one sandhill crane, and, regularly, an American bittern and a common snipe. The only species evident and common were passerines -- swamp sparrows, short-billed marsh wrens, northern yellowthroats, and red-winged blackbirds. I frequently listened for calls at dawn and dusk. Undoubtedly use of a small boat or waders would have allowed me to discover more of the secretive migrants, but probably not unusual concentrations.

The Stockton Island Bog and, to a lesser extent, the Michigan Island Bog also attracted water birds in small numbers. At Stockton, one crane and pied-billed grebes were regularly seen, along with up to 3 American bitterns.

THE SIGNIFICANCE OF THE BEAVER CLEARINGS

Beaver interrupt forested areas with shallow ponds and clearings and their activity has frequently been cited as beneficial to wildlife. Waterfowl use of beaver ponds for nesting and migration has received most careful study (Evans, 1948; Hodgdon and Hunt, 1955; Wright, 1956). Some observers (Carr, 1940; Shelton, 1960; Swank, 1949) have stated that beaver cause habitat changes favorable to woodcock and many non-game bird species. Knudson (1962) in Wisconsin collected no objective data, but believed bird densities were greater in beaver clearings than along the streams above and below. The species benefited included shorebirds, swallows, flycatchers, hawks, warblers, sparrows, and kingfishers. Quantitative data assessing beaver impacts on non-game birds have not been published.

On Outer Island, beaver clearings would appear to have particular value. Beaver also are present on Stockton and, at least formerly, on Michigan Island. Beaver create frequent open spaces in otherwise almost unbroken forest.

At north Outer, I noted numerous bird species primarily or solely at beaver clearings. These included common snipe, kingfisher, phoebe, olive-sided flycatcher, short-billed marsh wren, common grackle, red-winged blackbird, rusty blackbird, swamp sparrow, and yellowthroat, Wilson's, chestnut-sided, mourning, and Connecticut warblers. Tree swallows nested in the stumps of birches drowned by beaver. I found pileated woodpeckers only in forest areas immediately adjacent to beaver clearings.

The beaver clearings drew birds normally inhabiting other habitats that could not find more suitable areas nearby. These strays included a meadowlark perched atop a dead conifer, a long-billed marsh wren in an alder thicket, and an American bittern. The bittern appeared at beaver works of very limited extent, hardly breaking the forest canopy. I flushed the bird from the water edge, and it landed on a hemlock branch near the trunk, assuming the upright posture used by the species in hiding among cattails.

The beaver clearings did attract waterfowl, often sheltering mallards, black and wood ducks, and green-winged and blue-winged teal. I believe all these species nested, although I found definite evidence only for the green-winged teal and black duck. I had one sighting of a female bufflehead, at Gray Dam.

The presence of beaver appears to have a significant positive effect for non-forest migrant birds. In particular, my observations suggest that migrants are attracted to the clearings in greater densities than to the surrounding habitat. I have analyzed my data from the morning station counts at Outer's north end to test this hypothesis.

Of my 16 count stations on north Outer, six were near the lakeshore and meadow, and have been discarded from this analysis. Of the remaining ten stations, five were in forested areas partially cleared and flooded by beaver. The other five were in forest areas unaltered by beaver. On 13 mornings, I took counts at each of the one-hectare stations.

In Table 15, I contrast my data for the areas affected by beaver (Group 1) with data for the areas unaffected by beaver (Group 2). To compare the two groups, I used the non-parametric Mann-Whitney Rank Test because my data did not follow a normal distribution. Areas affected by beaver held more species and more individuals per station per day than did unaffected areas, a difference significant at the .004 level. Similarly, the total number of species recorded at each site over the thirteen mornings was greater for the stations affected by beaver than for those stations not affected, the difference being statistically significant at the .01 level.

Shannon's function (Shannon and Weaver, 1963) has been widely used to describe species diversity in natural communities:

$$H' = \sum_{i=1}^S p_i \log_2 p_i$$

where p_i is the proportion of individuals in the i^{th} species ($i=1,2,3,\dots,S$). This diversity measure has two components, species richness and relative species abundance (Lloyd and Ghelardi, 1964). The number of species present, S , represents species richness. The following formula used by Tramer (1969) provides a measure of relative abundance:

$$J' = H'/H'_{\max}$$

where H'_{\max} is $\log_2 S$. This is the ratio of observed diversity to maximum diversity possible for the number of species present. This maximum value is obtained when all species are equally abundant.

For my data I obtained average values of 2.69 for H' and 0.90 for J' in the five areas affected by beaver (Group 1), and 2.08 for H' and 0.91 for J' in five unaffected areas (Group 2).

The high J' values approach the maximum possible measure for relative species abundance, when observed diversity equals maximum diversity and J' equals 1.0. The closely similar J' values for Groups 1 and 2 indicate that beaver impact on bird diversity can be almost entirely explained by changes in the number of species present. Tramer (1969) obtained similar results for breeding bird populations in a wide variety of habitats, but did not analyze data for migratory birds.

Table 15. A Comparison of Bird Use of Areas Affected by Beaver and of Areas Unaffected by Beaver*

	<u>Group 1. Areas Affected by Beaver</u>	<u>Group 2. Areas Unaffected by Beaver</u>
Species per station per day**	6.0	3.2
Individuals per station per day**	9.5	4.2
Total species per station for 13 days***	35.4	22.2
Total species for 5 stations for 13 days	73	45

* Data based on counts made on 13 mornings at 5 stations in each category

** Significant difference between Groups 1 and 2 at the .004 level

*** Significant differences between Groups 1 and 2 at the .01 level.

The presence of beaver increases the overall diversity of birds on Outer Island. The situation here still approximates what once must have been the character of much of eastern North America, before white settlement and the extensive clearing of forests. At that time, many bird species probably depended heavily on beaver for nest habitat. While this dependency no longer remains, in isolated areas like Outer beaver clearings still have high survival value for migrants.

THE APOSTLE ISLANDS AS A CONCENTRATION AREA FOR MIGRANTS

The high counts of hawks and of passerines discussed in previous sections indicate that migrants do heavily concentrate in the Apostle Islands in spring, particularly on Outer Island. However, on Outer, the size of the reverse migration causes use of the island for resting and feeding to be less strikingly unusual than the flights themselves.

The variety of birds visiting the Apostles is great. During the two seasons, 201 species were identified: 183 in 1976, and 177 in 1977. The highest one-day count, of 111 species, came on May 28, 1976, on Outer Island. It would be very difficult to find an equal variety as far north as Outer in a similarly small (8,000-acre) area.

Water birds of northern Wisconsin were less completely represented than were landbirds. All Falconiformes -- except the golden eagle -- normally appearing in the state were recorded. I found 25 species of warblers and 16 species of sparrows (the only regularly occurring Wisconsin sparrows missed were the sharp-tailed and the fox). Appendix C contains an annotated checklist of all species noted.

The Apostle Islands' position relative to the mainland and Lake Superior are further reflected in the presence of birds out of habitat or out of range. Some of these, at beaver clearings, were cited in the last section. Other records deserve mention. On May 20, a field sparrow was foraging within a forest bordering Outer's bog. Once in 1976 and twice in 1977 single LeConte's sparrows were resting at damp spots within forest, far from any marshlands. In 1977, a long-billed marsh wren appeared on rock ledges between the forest and the lake on Stockton.

Unusual were mockingbirds seen at Outer's south tip on six days between May 13 and 28 in 1976, and on 4 days between April 30 and June 2, 1977. A very late winter-plumaged Lapland longspur remained on Sand Point from May 25 to 28, 1976. Near it, on May 27, I discovered a male chestnut-collared longspur in full breeding plumage. Northern species included 5 gray jays on Devil's Island, single black-backed three-toed woodpeckers twice on Outer, and a late snowy owl, on May 3, 1977, at Austad Bay, where there is no open country.

Noteworthy also during the study period were turkey vultures, a peregrine falcon, an Iceland gull, a piping plover, whimbrel on 4 occasions, a willet, a Hudsonian godwit, and a knot.

Of the Apostles, only Outer appears to have flights large enough to serve as a primary attraction for visitors, for a period running from the end of April through late May. At many of the other Apostles, migration may prove to be an important and delightful, but secondary, attraction for lakeshore visitors.

Even Outer, because of its small size and inaccessibility, would be unlikely to draw the great numbers of bird watchers that annually travel to Point Pelee, Block Island, and similarly well-known migration look-outs. But the undisturbed condition of these islands and the lake make nature study here a particularly high quality experience. Once known, the patterns and magnitude of migration should be of great interest.

Outer Island, and the Apostles generally, do comprise an ideal area for the study of Lake Superior's impact on migrants.

AREAS OF SPECIAL VALUE

Here I consider portions of the Apostles with significant value for the migrants themselves and for humans who would like to watch them.

Outer Island

1. The island's south end has greatest value. Habitat is most varied here, much of it unduplicated anywhere else on Outer or, indeed, on any of the northern or central Apostles except Stockton Island. Sand Point is important for shorebirds, South Pond for ducks and marsh birds, the grasslands edging the beaches for open country passerines, and the mixed coniferous and deciduous forests shelter the highest concentrations of warblers and other forest species on the island.

The close proximity of these different habitats make south Outer ideal for watching birds. The large and extraordinary flights heading south from Outer can here be observed. Aside from birds, south Outer is a very enjoyable place for humans to visit, with its beaches, interior lake, open areas, and excellent views of the other Apostles.

2. The beaver clearings are important for migrants of many species. They have been discussed in a previous section.

3. The lighthouse and the small meadow around it provide an excellent vantage point for watching the hawk flights and the responses of other migrants to the open lake. The meadow is the only unforested area along the north shore. Hawks and passerines often rest in the meadow or at its edges. This dry, grassy spot attracts certain sparrows and other passerines for which the damp, partially overgrown beaver clearings are hardly suitable.

4. Austad Bay has wide rock ledges that allow good migration watching. The bay, sheltered from all but easterly winds, is a particularly beautiful spot.

5. The abandoned lumber roads provide the only practical means for people to move overland from one portion of Outer to another.

Stockton Island

1. The bog at Presque Isle Point attracts an interesting variety of resident and migrant water birds. The open area of beach to the east also favors some species. The Presque Isle Point area, with its variety of habitats, provides excellent bird watching.

Michigan Island

1. The beach at the west end attracts shorebirds. In the fall, it has large passerine flights, and the forest all along its edge shelters many migrants.

2. The bog near the northwest end of the island attracts small numbers of water birds that have no other habitat on the island. Birds here are easily disturbed by people.

Devil's Island

1. The forest at the south end hosts large numbers of migrants, making this area of special interest to bird watchers.

MANAGEMENT RECOMMENDATIONS

My recommendations are grouped according to the high value areas I describe in the last section.

Outer Island

1. Birds in migration are far less vulnerable to human disruption than during the breeding season. Small numbers of people on Outer's south end will have no impact on the transitory birds, but a pier and major camp ground would cause substantial negative impact. The south end should be left as it now is, with access only by charter boat for those willing to make the special arrangements. A small, primitive camp ground might be constructed. If it is created it should be placed on the east shore 2/3 mile or more from the south tip, as located in the National Lakeshore's Master Plan (U.S. Department of Interior, 1971). This location would minimize disturbance of migrants. Visitors interested in migration could also be encouraged to camp at locations in the Apostles other than at Outer -- such as Presque Isle Point or the west end of Michigan Island -- thus mitigating human impacts. Additional research will be required to identify other sites, including possibly Point Detour on the mainland, the north tip of Sand Island, and the south ends of York and Cat Islands.

If visitor use increases, the beach top between the lake on the west and Outer's bog will be highly vulnerable to erosion. Wood steps should be built at one place to discourage climbing up the dry sand elsewhere.

2. Beaver should be protected from human disturbance, and approach to clearings should be carefully controlled. Trails should be constructed to avoid beaver, except for observation sites that are distant from dams and lodges but have wide views. The effects of beaver on the land, forests and other animals (particularly birds) could make an excellent interpretive booklet or program.

In 1976, the beaver population on Outer appeared high to me. Trapping should be carefully regulated, so that excess animals are removed without decreasing the size or number of settlements. A qualified observer should assess the status of the beaver population on Outer (and on the other Apostles individually) before trapping limits are determined.

3. The meadow surrounding the lighthouse should be kept unforested, as habitat for migrants and as a hawk observation area. The top of the

lighthouse provides a view of the hawk flights far out over the forest, and if possible should be open for visitors.

This area would be a poor place for a camp ground of large size, for the pier is exposed to storms from the west, north and east. But if interest in north Outer were to grow, I would suggest construction of an outhouse, placement of trash barrels, and creation of several sites for tents just within the forest edge.

4. Austad Bay should retain its undisturbed appearance. If hiking on Outer were to be encouraged, several tent sites might be cleared near the forest edge.

5. Outer Island has great attraction for bird watchers and others because of its primitive condition. I recommend that no clearings be created, no areas of habitat be altered to benefit certain wildlife species, and no buildings be constructed. However, the lumber roads are essential for minimum access to the island interior, and at least some of them should be maintained. They should remain as footpaths, not roads. The main north-south route is most important. Many of the sidepaths are non-essential, but the spur to Austad Bay has value. I recommend that one or more additional paths be preserved to Outer's rocky east shore, and also to the west coast with its tall bluffs of clay.

In so far as possible, paths should be rerouted around beaver settlements. At present, travelers of the main north-south road must pass over or immediately beside dams of seven beaver colonies. Even light human activity along the present road could have a strong negative impact.

Stockton Island

1. The bog area should be posted to prevent human entry (or too close an approach) and disturbance of plants and animals. The upper edges of the beach are particularly vulnerable to erosion and will be quickly damaged if many visitors cross it. An interpretive pamphlet should be available to visitors on the island, explaining the nature of the bog and beach, their values and fragility.

Michigan Island

1. I see no particular management needs for the west beach.

2. Signs should be erected warning people of the fragility and value of the bog. The sand edges on its north side are especially vulnerable.

Devil's Island

1. A short trail about the south end, perhaps forming a loop, would allow visitors to see more of the unusual variety of birds here.

Finally, I recommend that, as the migrations through the Apostles become better known, an interpretive booklet be prepared explaining these twice annual phenomena.

FUTURE STUDY

Lake Superior has a substantial effect on land bird migration. Many opportunities exist for collection of data that will greatly increase understanding of migratory patterns in the region.

Within the Apostles, observations similar to those already obtained should be continued. More extensive data will be most useful from Outer, because birds are most concentrated here, or concurrently from Outer and one or more of the other islands. Stockton, Michigan and Devil's are all worth further visits. In addition, Eagle, York, North Twin and Cat Islands may prove to be of special interest.

Use of radar in conjunction with visual observations would allow more precise conclusions that would also be more generally applicable.

Observations of fall migration would complement the spring studies, with valuable results. Autumn flight patterns within the islands are different. Species composition of the flights, after the lake crossing, would provide clues about the lake effect that are unobtainable in spring.

Elsewhere along Superior's south shore, the Keweenaw Peninsula, Whitefish Point, and both ends of the lake are most ideal for study. Bird behavior at extensions of land into Superior from the north should also be investigated. All these studies would be most useful if conducted concurrently with Apostle Islands observations.

Study of migration at shorelines away from peninsulas or island groups should also be undertaken, documenting behavior of migrants as they encounter Superior's shoreline away from special concentration areas.

SUMMARY

The behavior of land bird migrants in the Apostle Islands was studied to determine the significance of these islands as stopover locations and to outline how Lake Superior affects migration patterns. Field observations extended from late April until early June of 1976 and 1977, with most data collected from Outer Island. In 1977, Stockton, Devil's, and Michigan Islands also were visited. Results apply only to migrants flying low enough to be visible from the ground.

By day the great majority of north-flying passerines and raptors turned about upon encountering the open lake at the north shores of Outer and Devil's Islands. In the early morning, passerines that migrated by night were also observed flying south off the lake onto the islands. A small number of day migrants headed north across Superior.

Results indicated that the south tip of Outer is the best observation site in the Apostles. A large reverse migration was observed here, and to a lesser extent off south Devil's, directed south toward the inner islands. On Outer, as many as 500 hawks were visible at once, and up to 3100 passerines were counted in flight within a half hour period.

On the inner Apostles, raptors and passerines were noted flying north, south, and parallel to the shoreline, as if hesitant to cross water. But concentrations on these islands did not approach the size of flights off south Outer.

Future systematic observations among the Apostles are recommended, particularly in the fall, or in spring from several islands simultaneously. Information about migrant behavior along other portions of the Lake Superior shoreline would allow more general conclusions about the lake's impact on migration.

LITERATURE CITED

- Able, K. P. 1972. Fall migration in coastal Louisiana and the evolution of migration patterns in the Gulf region. Wilson Bulletin. 84: 231 - 242.
- Able, K. P. 1973. The role of weather variables and flight direction in determining the magnitude of nocturnal bird migration. Ecology. 54: 1031 - 1041.
- Allen, R. P. and R. T. Peterson. 1936. The hawk migrations at Cape May Point, New Jersey. Auk. 53: 393 - 404.
- Bagg, A. M. 1969. The changing seasons -- a summary of the fall migration season, 1968 with special attention to the movements of black-capped chickadees. Audubon Field Notes. 23: 4 - 12.
- Baird, J. and I. C. T. Nisbet. 1960. Northward fall migration on the Atlantic coast and its relation to offshore drift. Auk. 77: 119 - 149.
- Beebe, R. 1933. Influence of the Great Lakes on the migration of birds. Wilson Bulletin. 45: 118 - 121.
- Binford, L. C. 1965. Unusual bird records from the upper peninsula of Michigan. Jack-Pine Warbler. 43: 144 - 145.
- Booth, W. M. 1969. Birds of the Benton Harbor - St. Joseph waterfront. Jack-Pine Warbler. 47: 44 - 54.
- Booth, W. M. 1971. Migration of blue jays in southwestern Michigan. Jack-Pine Warbler. 49: 82 - 86.
- Brewster, W. 1886. Bird migration. Memoirs of the Nuttall Ornithological Club. 1: 19 - 21. Cited in Van Tyne, J. and A. J. Berger. 1959. Fundamentals of Ornithology. John Wiley and Sons, New York. 624 pages.
- Carr, W. H. 1940. Beaver and birds. Bird Lore. 42: 141 - 146.
- Curtis, S. G. 1969. Spring migration and weather at Madison, Wisconsin. Wilson Bulletin. 81: 235 - 245.

- Dobben, W. H. van. 1953. Bird migration in the Netherlands. Ibis. 95: 212 - 234.
- Dorst, J. 1962. The Migrations of Birds. Translated by C. D. Sherman. Heinemann, London. 476 pages.
- Drury, W. H. and J. A. Keith. 1962. Radar studies of songbird migration in coastal New England. Ibis. 104: 449 - 489.
- Eastwood, E. and G. C. Rider. 1965. Some radar measurements of the altitude of bird flight. British Birds. 58: 393 - 426.
- Evans, P. R. 1966. An approach to the analysis of visible migration and a comparison with radar observations. Ardea. 54: 14 - 44.
- Evans, T. R. 1948. Beaver - Trout - Waterfowl Problems. Paper presented at the 10th Midwest Wildlife Conference, Wildlife Management Institute, Ann Arbor, Michigan. 15 pages.
- Forsyth, B. J. and D. James. 1971. Springtime movements of transient nocturnally migrating landbirds in the Gulf Coastal Bend region of Texas. Condor. 73: 193 - 207.
- Gauthreaux, S. A., Jr. and K. P. Able. 1970. Wind and the direction of songbird migration. Nature. 228: 476 - 477.
- Green, J. C. 1962. Arrested passerine migration and kill at Lake Superior. Flicker. 34: 110 - 112.
- Gunn, W. W. H. 1948. Reverse migration over Lake Erie. Wilson Bulletin. 60: 67.
- Harris, J. T. and S. W. Matteson. 1975. Gulls and Terns as Indicators of Man's Impact Upon Lake Superior. Technical Report Number 227, University of Wisconsin Sea Grant College Program, Madison, Wisconsin. 45 pages.
- Haugh, J. R. 1972. A study of hawk migration in eastern North America. Search Agriculture. 2: 1 - 60.
- Hebrard, J. J. 1972. Fall nocturnal migration during two successive overcast days. Condor. 74: 106 - 107.
- Heintzelman, D. S. 1975. Autumn Hawk Flights. The Migrations in Eastern North America. Rutgers University Press, New Brunswick, New Jersey. 398 pages.
- Hodgdon, K. W. and J. H. Hunt. 1955. Beaver Management in Maine. Game Division Bulletin Number 3, State of Maine Department of Inland Fisheries and Game, Augusta. 102 pages.

- Hofslund, P. B. 1966. Hawk migration over the western tip of Lake Superior. Wilson Bulletin. 78: 79 - 87.
- Kelley, A. H. 1972. Spring migration at Whitefish Point, 1966 - 1971. Jack-Pine Warbler. 50: 69 - 75.
- Kelley, A. H. 1973. Additional notes on the 1973 spring migration at Whitefish Point. Jack-Pine Warbler. 51: 163 - 164.
- Kelley, A. H. and J. O. L. Roberts. 1971. Spring migration of owls at Whitefish Point. Jack-Pine Warbler. 49: 64 - 70.
- Kelley, N. T. and A. H. 1973. Fall migration at Tawas Point. Jack-Pine Warbler. 51: 111 - 115.
- Kleiman, J. P. 1966. Migration of rough-legged hawks over Lake Erie. Wilson Bulletin. 78: 122.
- Knudsen, G. J. 1962. Relationship of Beaver to Forests, Trout and Wildlife in Wisconsin. Technical Bulletin Number 25, Wisconsin Conservation Department. 52 pages.
- Lack, D. 1959. Migration across the sea. Ibis. 101: 374 - 399.
- Lack, D. 1960a. The height of bird migration. British Birds. 53: 5 - 10.
- Lack, D. 1960b. The influence of weather on passerine migration. A review. Auk. 77: 171 - 209.
- Lack, D. and E. 1952. Visible migration at Land's End. British Birds. 45: 81 - 96.
- Lake Superior Project. 1972 - 73. Environmental Decisions: Policies and Guidelines for the Lake Superior Region, Part 1: The Year's Work in Review 1972-1973. Madison, Wisconsin. 98 pages.
- Lewis, H. F. 1939. Reverse migration. Auk. 56: 13 - 27.
- Lloyd, M. and R. J. Ghelardi. 1964. A table for calculating the 'equitability' component of species diversity. Journal of Animal Ecology. 33: 217 - 225.
- Lowery, G. H., Jr. 1945. Trans-Gulf spring migration of birds and the coastal hiatus. Wilson Bulletin. 57: 92 - 121.
- Magee, M. J. 1922. Hawk migration route at Whitefish Point, Upper Peninsula of Michigan. Auk. 39: 257 - 258.

- Merriam, C. H. 1885. Bird migration at the Straits of Mackinac. Auk. 2: 64.
- Mueller, H. C. and D. D. Berger. 1965. A summer movement of broad-winged hawks. Wilson Bulletin. 77: 83 - 84.
- Mueller, H. C. and D. D. Berger. 1967a. Fall migration of sharp-shinned hawks. Wilson Bulletin. 79: 397 - 415.
- Mueller, H. C. and D. D. Berger. 1967b. Wind drift, leading lines, and diurnal migration. Wilson Bulletin. 79: 50 - 63.
- Mueller, H. C. and D. D. Berger. 1969. Navigation by hawks migrating in spring. Auk. 86: 35 - 40.
- Nisbet, I. C. T., W.H. Drury, Jr., and J. Baird. 1963. Weight-loss during migration. Part one: deposition and consumption of fat by the blackpoll warbler Dendroica striata. Bird-Banding. 34: 107 - 138.
- Peet, M. M. 1908. The fall migration of birds at Washington Harbor, Isle Royale, in 1905. In Ecology of Isle Royale, Michigan Survey, 1908, Pages 97 - 119.
- Perkins, J. P. 1964. A ship's officer finds 17 flyways over the Great Lakes -- Part I. Audubon. 66: 294 - 299.
- Perkins, J. P. 1965. A ship's officer continues his story: 17 flyways over the Great Lakes -- Part II. Audubon. 67: 42 - 45.
- Pettingill, O. S., Jr. 1964. Spring migration at Point Pelee. Audubon. 66: 78 - 80.
- Plunkett, R. L. 1969. The 1969 spring migration: a season of contrasts. Audubon Field Notes. 23: 564 - 567, 628.
- Postupalsky, S. 1976. Bald eagle migration along the south shore of Lake Superior. Jack-Pine Warbler. 54: 98 - 104.
- Rabøl, J. 1969. Reversed migration as the cause of westward vagrancy by four Phylloscopus warblers. British Birds. 62: 89 - 92.
- Richardson, W. J. 1971. Spring migration and weather in eastern Canada: a radar study. American Birds. 25: 684 - 690.
- Richardson, W. J. 1972. Autumn migration and weather in eastern Canada: a radar study. American Birds. 26: 10 - 17.
- Royal Astronomical Society of Canada (ed. J. R. Percy). 1976. The Observer's Handbook 1976. Toronto. 116 pages.

- Royal Astronomical Society of Canada (ed. J. R. Percy). 1977. The Observer's Handbook 1977. Toronto. 120 pages.
- Rudebeck, G. 1950. Studies on bird migration based on field studies in southern Sweden. Var Fagelvarld. Supplementum I: 1 - 148.
- Schorger, A. W. 1961. Migration of blue jays at Madison, Wisconsin. Wilson Bulletin. 73: 393 - 394.
- Shannon, C. E. and W. Weaver. 1963. The Mathematical Theory of Communication. University of Illinois Press, Urbana. 117 pages.
- Sheldon, W. 1965. Hawk migration in Michigan and the Straits of Mackinac. Jack-Pine Warbler. 43: 79 - 83.
- Shelton, P. C. 1960. The Beaver of Isle Royale National Park, Michigan. First Annual Report. Manuscript, Department of Forestry and Conservation, Purdue University, Lafayette. 4 pages.
- Snow, D. W. 1953. Visible migration in the British Isles: a review. Ibis. 95: 242 - 270.
- Speirs, J. M. 1956. The migratory phase of robin behavior. Bulletin. Federation of Ontario Naturalists. 72: 20 - 27.
- Stadnyk, L., R. L. Verch, and B. A. Goetz. 1974. Stockton Island Survey. Northland College, Ashland, Wisconsin. 71 pages.
- Svardson, G. 1953. Visible migration within Fenno-Scandia. Ibis. 95: 181 - 211.
- Swank, W. G. 1949. Beaver Ecology and Management in West Virginia. Bulletin Number One, Division of Game Management, Conservation Commission of West Virginia. 65 pages.
- Taverner, P. A. and B. H. Swales. 1907. The birds of Point Pelee. Wilson Bulletin. 19: 37 - 54.
- Thomson, A. L. 1953. The study of the visible migration of birds: an introductory review. Ibis. 95: 165 - 180.
- Tramer, E. J. 1969. Bird species diversity: components of Shannon's formula. Ecology. 50: 927 - 929.
- Tyrrell, W. B. 1934. Bird notes from Whitefish Point, Michigan. Auk. 51: 21 - 26.
- United States Department of the Interior. 1971. Apostle Islands National Lakeshore, Master Plan. 30 pages.

Van Tyne, J. and A. J. Berger. 1959. Fundamentals of Ornithology.
John Wiley and Sons, New York. 624 pages.

Weir, R. D. 1972.. Spring migration at Prince Edward Point, Ontario.
Canadian Field Naturalist. 86: 3 - 16.

Wilcock, J. 1964. Radar and visible migration in Norfolk, England:
a comparison. Ibis. 106: 101 - 109.

Wood, N. A. 1933. Birds of Keweenaw Point, Michigan. Papers of
Michigan Academy of Sciences, Arts and Letters. 17: 713 - 733.

Wright, B. S. 1956. The Relation of Beaver to Moose and Woodcock..Manuscript,
Northeastern Wildlife Station, University of New Brunswick,
Fredericton. 23. pages.

Appendix A. Bird Species Observed Whose Northward Migratory Flight
Was Halted at Outer's North Shore.

double-crested cormorant	black-capped chickadee
great blue heron	robin
black-crowned night heron	cedar waxwing
turkey vulture	starling
sharp-shinned hawk	parula warbler
Cooper's hawk	yellow-rumped warbler
red-tailed hawk	chestnut-sided warbler
broad-winged hawk	palm warbler
rough-legged hawk	bobolink
bald eagle	meadowlark sp.
marsh harrier	red-winged blackbird
osprey	rusty blackbird
peregrine falcon	common grackle
merlin	brown-headed cowbird
kestrel	scarlet tanager
sandhill crane	indigo bunting
snowy owl	pine siskin
common flicker	American goldfinch
eastern kingbird	savannah sparrow
blue jay	dark-eyed junco
common raven	chipping sparrow
common crow	snow bunting

The following additional species turned about at Devil's Island's north shore: pintail, tern sp., yellow-headed blackbird, northern oriole.

Appendix B. Bird Species Identified Flying South Off Outer
Toward Stockton Island.

double-crested cormorant	veery
sharp-shinned hawk	eastern bluebird
Cooper's hawk	ruby-crowned kinglet
red-tailed hawk	water pipit
broad-winged hawk	cedar waxwing
rough-legged hawk	starling
marsh harrier	solitary vireo
kestrel	black and white warbler
ruby-throated hummingbird	orange-crowned warbler
kingfisher	Nashville warbler
mourning dove	magnolia warbler
cuckoo sp.	Cape May warbler
common flicker	yellow-rumped warbler
red-headed woodpecker	black-throated green warbler
eastern kingbird	blackburnian warbler
least flycatcher	chestnut-sided warbler
horned lark	palm warbler
blue jay	ovenbird
common raven	redstart
common crow	bobolink
black-capped chickadee	meadowlark sp.
nuthatch sp.	yellow-headed blackbird
mockingbird	red-winged blackbird
robin	northern oriole
hermit thrush	rusty blackbird
olive-backed thrush	common grackle

brown-headed cowbird
scarlet tanager
rose-breasted grosbeak
evening grosbeak
purple finch
pine siskin
American goldfinch

savannah sparrow
dark-eyed junco
chipping sparrow
clay-colored sparrow
white-crowned sparrow
white-throated sparrow
song sparrow

The following additional species were seen flying south off Devil's Island: yellow warbler, Canada warbler, indigo bunting.

Appendix C. Annotated Checklist of Birds Observed on Outer Island in 1976, and on Outer, Stockton, Devil's, and Michigan Islands in 1977.

Although records of arrivals, departures, and numbers of birds were made during both springs, this data was merely an incidental part of the field studies. The information presented here is therefore simply a summary of our notes and undoubtedly represents with varying precision the true status of the many species. I believe abundance and migratory periods are understated for those species less easily discovered. Field methods were distinctly different during the two years, and this difference affected the frequency with which some species were detected. For example, the relative scarcity of eastern phoebes, winter wrens, and northern water-thrushes in 1977 was probably in part an artifact of our observation techniques.

I made no guesses about the breeding status of birds in the Apostles. Asterisks (*) mark those species definitely known to have nested in one or both years, because of the discovery of nests, of adults with young, or of individuals on specific territories for prolonged periods. Obviously, most species actually breeding have not been identified here.

Where two dates are given to indicate a bird's arrival or departure, the first refers to 1976 and the second, in parentheses, to 1977.

For most of the more common warblers, relative abundance is indicated by the totals for each species recorded on the 16-station counts that were run on 23 mornings between May 8 and June 3, 1976. The most common warblers during this period were, in descending order, yellow-rumped, chestnut-sided, black and white, American redstart, Nashville, ovenbird, black-throated green, yellowthroat, and palm.

1. *Common loon Gavia immer -- present throughout period, with up to 6 observed at once. Nested on South Pond.
2. Horned grebe Podiceps auritus -- observed on lake daily until May 8 (May 10, 15 and 17); maximum of 8 on April 28, 1976.
3. Pied-billed grebe Podilymbus podiceps -- scattered observations off the north shore of Outer and at South Pond until May 8 (May 4), with a high count of 4 on April 30, 1976; on May 5, 1977, single birds sighted at two interior beaver ponds; present throughout observations at bogs on Stockton and Michigan Islands; sighted on May 27, 1977 off Devil's Island.

4. Double-crested cormorant Phalacrocorax auritus -- 17 sightings between May 8 (April 29) and May 19 (June 2), high count of 17 on May 17, 1977; always on or near the lake.
5. Great blue heron Ardea herodias -- present throughout period, in flight at lakeshore; high count of 6 on May 3, 1977.
6. Green heron Butorides virescens -- 1 at bog on Michigan Island, May 30, 1977.
7. Black-crowned night heron Nycticorax nycticorax -- 3 flying south from Outer's north end on May 15, 1976.
8. American bittern Botaurus lentiginosus -- observed May 7 (April 29) on, at bogs on Outer and Stockton Islands and at interior beaver ponds; high count of 3 on May 24, 1977.
9. Canada goose Branta canadensis -- 6 sightings between April 27 (May 3) and June 2 (May 30), high count of 12 on April 27, 1977; in flight or on open lake.
10. Snow goose Chen caerulescens -- 8 (1 snow, 7 blue phase) flying across Superior from Austad Bay on May 5, 1977.
11. *Mallard Anas platyrhynchos -- frequent on interior ponds throughout period, occasionally on open lake; high count of 24 on June 2, 1977.
12. *Black duck Anas rubripes -- throughout period in interior; adult with 8 ducklings observed at Three Lakes on May 28, 1976; ground nests with eggs discovered on May 8 and 23, 1977.
13. Gadwall Anas strepera -- 2 off Outer lighthouse pier, May 4, 1977.
14. Pintail Anas acuta -- 2 in flight off north Devil's on May 29, 1977 and 1 on lake at south Outer, June 2, 1977.
15. *Green-winged teal Anas crecca -- present May 1 (April 29) on, high count of 6 on May 9, 1976 and May 3, 1977; nest with 8 eggs discovered at Three Lakes on May 18, 1976.
16. Blue-winged teal Anas discors -- observed April 29 (April 29) on, generally in island interiors.
17. American widgeon Anas americana -- at south end of Outer, 1 on May 13 and 2 on May 14, 1976, and 4 on May 10, 1977.
18. Northern shoveler Anas clypeata -- one with teal on Michigan Island bog, May 26, 1977.
19. Wood duck Aix sponsa -- observed April 27 (April 29) on, in island interiors; high count of 10 on Michigan Island, May 28, 1977.

20. Ring-necked duck Aythya collaris -- pair on April 26 and 1 on May 13, 1976, 11 on April 29, 1977; all on South Pond.
21. Greater scaup Aythya marila -- 1 in flight off south Outer on May 8, 1977.
22. Lesser scaup Aythya affinis -- 7 flew by Sand Point on May 13, 1976; pair on Stockton bog, May 21, 1977.
Scaup sp. -- 4 on Stockton bog, May 15, 1977.
23. Common goldeneye Bucephala clangula -- 1 female off north Outer on April 29, 1 female off Presque Isle Point, on May 15, 1977, 2 off south Devil's on May 27, 1977.
24. Bufflehead Bucephala albeola -- observed 14 times between April 26 (April 28) and May 23 (June 1), high count of 5 on May 16, 1977; sighted in lake, at South Pond and three times at interior beaver ponds.
25. Hooded merganser Lophodytes cucullatus -- single birds on May 9 and 11, 1977, 2 on May 7, 1976 and May 14, 1977; on interior wetlands
26. Common merganser Mergus merganser -- present throughout period, high count of 9 on April 29, 1976.
27. Red-breasted merganser Mergus serrator -- present throughout period, high count of 18 on May 5, 1977.
28. Turkey vulture Cathartes aura -- 55 observed between April 29 (April 29) and May 29 (May 28), high count of 8 on May 28, 1976.
29. Goshawk Accipiter gentilis -- 1 immature plumaged at Outer lighthouse on April 29, 1976.
30. Sharp-shinned hawk Accipiter striatus -- 1,230 observed between April 27 (April 29) and June 2 (June 2); high counts of 106 on April 30, 1976, 130 on May 1, 1977 and 146 on May 5, 1977.
31. Cooper's hawk Accipiter cooperii -- 37 observed between April 29 (April 29) and May 28 (May 12); maximum of 7 on April 29 and May 4, 1976.
32. Red-tailed hawk Buteo jamaicensis -- 151 counted between April 29 (April 29) and May 25 (June 2); high count of 19 on May 1, 1977.
33. Red-shouldered hawk Buteo lineatus -- single birds observed on May 8, 1976 and May 12 and 16, 1977.
34. Broad-winged hawk Buteo platypterus -- 4,804 counted between April 29 (April 29) and May 29 (June 3); high count of 830 over north end of Outer on May 9, 1976.
35. Rough-legged hawk Buteo lagopus -- 48 observed between April 29 (April 29) and May 10 (May 29); high count of 13 on April 29, 1976
36. Bald eagle - Haliaeetus leucocephalus -- 9 noted between April 26 (April 29) and May 15 (May 26); maximum of 3 on April 30, 1977.

37. Marsh harrier Circus cyaneus -- 57 counted between April 29 (April 29) and June 2 (May 29), with a high count of 9 on April 29, 1977.
38. Osprey Pandion haliaetus -- 14 observed between April 30 (April 30) and May 11 (May 29); high counts of 2 on April 30 and May 25, 1977.
39. Peregrine falcon Falco peregrinus -- 1 immature female over Outer's north end on May 10, 1976.
40. Merlin Falco columbarius -- 7 single birds observed, between April 29 (May 3) and May 13 (May 10).
41. *American Kestrel Falco sparverius -- 106 observed between April 28 (April 28) and June 3 (May 13); in 1977, nested on West Michigan.
42. Sandhill crane Grus canadensis -- 1 flying south from north Outer, May 4, 1976; 1 at South Pond on May 6 and 7, 1976 and May 10 to 13, 1977; 2 flew from south Outer toward Stockton on April 29, 1977; 1 present at Presque Isle Bog throughout my visit to Stockton.
43. Sora Porzana carolina -- 1 flushed from edge of South Pond on May 14, 1976.
44. Coot Fulica americana -- 1 on South Pond on May 13 and 14, 1976; 1 at Stockton bog on May 14 and 16, 1977; 1 off Michigan Island on May 28, 1977.
45. Semipalmated plover Charadrius semipalmatus -- observed on 8 occasions, between May 26 (May 22) and June 3 (May 28), all on south Outer except for the high count of 5 at Presque Isle Beach on May 22, 1977.
46. Piping plover Charadrius melodus -- 1 flying along sand shore of south Outer, May 21, 1976.
47. *Killdeer Charadrius vociferus -- present throughout period, observed on south Outer, Presque Isle Point, west Michigan, and occasionally north Outer.
48. Golden plover Pluvialis dominica -- at Sand Point on 6 occasions, between May 14 (May 12 only) and June 2; high count of 5 on May 14, 1976.
49. Black-bellied plover Pluvialis squatarola -- observed on 10 days between May 25 (May 15) and May 28 (June 2); high count of 5 on May 26, 1977.
50. Ruddy turnstone Arenaria interpres -- present between May 25 (May 20) and June 3 (June 2), with a maximum of 21 on May 28, 1977; at south Outer and west Michigan.
51. *Woodcock Philohela minor -- present throughout period at clear areas and along interior roads.
52. Common snipe Capella gallinago -- observed from May 5 (April 29) until May 28 (May 31), with a maximum of 24, in flight at south Outer on May 1, 1977; heard winnowing at South Pond both years; otherwise at wet interior areas, all but once beaver clearings, and once at the Michigan bog.

53. Whimbrel Numenius phaeopus -- 7 over Sand Point on May 25, 1976; 3 at Presque Isle Beach, May 21, 1977; 1 on west Michigan beach on May 28 and June 2, 1977.
54. *Spotted sandpiper Actitis macularia -- present May 8 (May 4, 10) on, along island shores and once at a beaver clearing.
55. Solitary sandpiper Tringa solitaria -- 1 at north Outer May 11, 1976; 4 on South Pond on May 13 and 1 on May 14, 1976.
56. Willet Catoptrophorus semipalmatus -- 1 at Presque Isle Bog on May 15, 1977.
57. Greater yellowlegs Tringa melanoleucus -- observed between April 27 (April 29) and May 9, 28 (May 12); at south Outer and once at north Outer; high count of 4 on May 8, 1976.
58. Lesser yellowlegs Tringa flavipes -- observed between May 12 (May 1, 7) and May 25 (May 16), at south Outer, once at north Outer, and at Presque Isle Bog; maximum of 3 on May 25, 1976.
59. Knot Calidris canutus -- 1 on Sand Point May 25 to 28, 1976.
60. Least sandpiper Calidris minutilla -- observed between May 13 (May 21) and May 28 (May 22), with a high count of 6 on May 28, 1976; unidentified "peep" observed in 1977 on May 8, and between May 14 and June 2, with a high count of 18 on June 2; at south Outer, Presque Isle Beach and Bog, and at west Michigan.
61. Dunlin Calidris alpina -- present May 13, 21 (May, 12, 23) through June 2 (June 2), with a high count of 33 on May 25, 1976; at south Outer and west Michigan.
62. Long-billed dowitcher Limodromus scolopaceus -- pair seen and heard at Presque Isle Bog on May 14, 1977.
63. Semipalmated sandpiper Calidris pusillus -- on south Outer May 25 (May 26 only) to June 2, maximum 2 on May 28; probably among "peep" on west Michigan May 31 to June 2, 1977.
64. Hudsonian godwit Limosa haemastica -- 1 on Sand Point May 26, 1977.
65. Sanderling Calidris alba -- observed between May 21 (May 6, 14) and June 2 (June 2), with a maximum of 3 on several days; at Sand Point and west Michigan.
66. Wilson's phalarope Steganopus tricolor -- pair at Presque Isle Bog on May 14, 1977.
67. Iceland gull Larus glaucoides -- an immature on Outer's lighthouse pier on May 1, 1976.

68. *Herring gull Larus argentatus -- present on all shores throughout period; in 1976, 4 nests at Sand Point, 2 with 3 eggs, 1 with 2 eggs, and 1 empty on May 25 and 26.
69. Ring-billed gull Larus delawarensis -- adult and immature-plumaged birds present throughout observation periods at south Outer, Presque Isle Beach, and west Michigan; also seen at Devil's, north Outer and northeast Stockton.
70. Bonaparte's gull Larus philadelphia -- 22 at Sand Point on May 28, 1976.
71. Black tern Chlidonias niger -- 2 over Presque Isle Bog on May 16, 1977.
72. Rock dove Columba livia -- single birds flying by Outer lighthouse on April 29 and Austad Bay on May 3, 1976.
73. Mourning dove Zenaida macroura -- observed between May 13 (April 30) and June 3 (June 2), with a maximum of 4 on May 12, 1977; at south Outer, once at Presque Isle Bog, and at west Michigan.
74. Black-billed cuckoo Coccyzus erythrophthalmus -- 1 on south Devil's on May 30, 1977.
75. Great horned owl Bubo virginianus -- in 1976, heard at Outer light on April 28 and 29, and at Austad on May 3; heard at Austad on June 2, 1977.
76. Snowy owl Nyctea scandiaca -- 1 at Austad May 3, 1977; it attempted to cross the lake north, but gull attacks sent it back to the island for shelter.
77. Barred owl Strix varia -- heard at 7 locations on 3 islands between May 8 (May 9) and June 2 (May 28).
78. Saw-whet owl Aegolius acadicus -- heard both east and west of Outer light on April 28 and to the west on April 29, 1976; heard by South Pond on May 7, both 1976 and 1977.
79. Whip-poor-will Caprimulgus vociferus -- heard under nearly full moon May 14, 1976 by South Pond.
80. Common nighthawk Chordeiles minor -- present May 26 (May 15, 20) on, with a high count of 6 on May 28, 1976; observed on 3 islands.
81. *Chimney swift Chaetura pelagica -- first noted May 12 (May 5); in 1976, roosted May 14 in engine house near Outer light, with a high count of 80 at dusk May 14.
82. Ruby-throated hummingbird Archilochus colubris -- observed May 25 (May 19) on, on 3 islands.
83. Belted kingfisher Megaceryle alcyon -- present throughout period by lake, bogs, and beaver clearings; more often noted in early weeks.

84. Common flicker Colaptes auratus -- present throughout period; most common in late April and early May, with a high count of 75 on April 29, 1977.
85. *Pileated woodpecker Dryocopus pileatus -- infrequently observed throughout period, at beaver clearings on Outer, near Presque Isle Bog and on west Michigan.
86. Red-headed woodpecker Melanerpes erythrocephalus -- observed between May 14 (May 10) and May 28 (May 29), on south Outer and once on west Michigan; high count 2 on May 27, 1976.
87. Yellow-bellied sapsucker Sphyrapicus varius -- present throughout period, more often noted in early weeks.
88. *Hairy woodpecker Dendrocopos villosus -- present throughout period.
89. *Downy woodpecker Dendrocopos pubescens -- present throughout period, much more common than the hairy woodpecker.
90. Black-backed three-toed woodpecker Picoides arcticus -- 1 in pines at base of Sand Point on May 19, 1977; 1 at Gorge Beavers on May 21, 1977.
91. Eastern kingbird Tyrannus tyrannus -- present May 15, 18 (May 12) on, high count of 18 on May 27, 1977; on 3 islands, most commonly south Outer.
92. Crested flycatcher Myiarchus crinitus -- present in small numbers May 19 (May 16) on.
93. Eastern phoebe Sayornis phoebe -- present throughout period in 1976, more common in early weeks; in 1977, not noted until May 19.
94. Yellow-bellied flycatcher Empidonax flaviventris -- present May 23 (May 27) on, high count of 4 on May 27, 1977.
95. Alder flycatcher Empidonax alnorum -- present June 2 (May 27) on, high count of 5 on June 2, 1977; at south Outer and on Devil's.
96. Least flycatcher Empidonax minimus -- May 12 (May 9) on, peak numbers on May 13, 1976 at south Outer.
97. Eastern wood peewee Contopus virens -- present May 26 (May 23) on.
98. Olive-sided flycatcher Nuttallornis borealis -- observed between May 22 (May 22) and May 28 (May 29), with a high count of 2 on May 28, 1976; at bogs and beaver clearings.
99. Horned lark Eremophila alpestris -- lone birds noted in flight and on Sand Point until the end of May, high count of 2 on May 13, 1976.
100. *Tree swallow Iridoprocne bicolor -- present throughout period, with a high count of 52 by Outer light on April 29, 1976; nested at beaver ponds in birches drowned by the dams.

101. *Bank swallow Riparia riparia -- May 9, 12 (May 12) on; small numbers nested near Outer light and at south Outer.
102. *Rough-winged swallow Stelgidopteryx ruficollis -- April 28, May 7 (May 2, 9) on; nested at north and south Outer; also at Presque Isle Bog.
103. *Barn swallow Hirundo rustica -- May 5, 10 (May 9) on; in 1976; single pairs nested at Outer's light and in the fishermen's shack at south Outer.
104. *Cliff swallow Petrochelidon pyrrhonota -- in 1976, 1 or 2 noted by Outer light on April 28, 29 and 30; 15 there at dusk on May 8 and breeding colony present from then on, nesting on light and engine house; in 1977, first noted on April 30; also nested on Devil's light and on rock ledges on northeast Stockton's shore.
105. Purple martin Progne subis -- 1 noted on south Outer April 30, 1977; 1 at west Michigan, May 30, 1977.
106. Gray jay Perisoreus canadensis -- up to 5 observed on north and south Devil's, between May 27 and June 3, 1977.
107. Blue jay Cyanocitta cristata -- observed throughout period, primarily in migrating flocks; high count of 520 on south Outer on May 13, 1977.
108. Common raven Corvus corax -- present throughout period, less frequent at south Outer than elsewhere on Outer.
109. Common crow Corvus brachyrhynchos -- present throughout period.
110. *Black-capped chickadee Parus atricapillus -- present throughout period, high counts of about 40 on May 3 and 28, 1977.
111. *White-breasted nuthatch Sitta carolinensis -- bred at Gray Dam in 1976; single birds noted at 4 times between May 10 and June 3, on Outer and Devil's Islands.
112. *Red-breasted nuthatch Sitta canadensis -- frequently observed throughout period, on all islands.
113. Brown creeper Certhia familiaris -- present throughout period, noted more in early weeks.
114. House wren Troglodytes aedon -- in 1976, single birds at south Outer on May 13, and at Three Lakes on May 18; in 1977, on Michigan on May 24.
115. Winter wren Troglodytes troglodytes -- in 1976, present throughout period at scattered interior locations on Outer; not noted on Outer in 1977, but present throughout visits to Stockton and Devil's.
116. Long-billed marsh wren Telmatodytes palustris -- 1 at Gray Dam May 30, 1976; 1 on Presque Isle Point on May 26, 1977.

117. Short-billed marsh wren Cistothorus platensis -- present May 8, 12 (May 6, 10) on, at beaver clearings, bogs, and other open areas.
118. Mockingbird Mimus polyglottos -- single birds noted May 13, 14, 18, and 21, 1976; 2 on May 27 and 28, 1976; in 1977, singles noted on April 30, May 19, 24, and 27, and June 2; all on south Outer.
119. Gray catbird Dumetella carolinensis -- present May 15, 19 (May 15) on; common in clearings.
120. Brown thrasher Toxostoma rufum -- May 8 (May 15) on.
121. *Robin Turdus migratorius -- present throughout period.
122. Wood thrush Hylocichla mustelina -- single birds noted 7 times between May 19 (May 23) and May 29 (May 27).
123. *Hermit thrush Catharus guttata -- present throughout period, much commoner in late April and early May; high count of 50 on May 6, 1976.
124. Swainson's thrush Catharus ustulata -- observed between May 22 (May 18) and June 3 (June 3).
125. Gray-cheeked thrush Catharus minima -- single birds noted between May 13 (May 14 only) and June 2.
126. Veery Catharus fuscescens -- present May 13 (May 16) on, in interiors and at south Outer.
127. Eastern bluebird Sialia sialis -- observed on 10 days between May 8 (May 9) and June 3 (May 28), high count of 4 on May 9, 1977; once on Devil's, all others on south Outer.
128. Golden-crowned kinglet Regulus satrapa -- in 1976, frequently noted through May 13, less often through June 3; in 1976, not noted after May 6 except on Devil's.
129. Ruby-crowned kinglet Regulus calendula -- present throughout period, much less common after mid-May (in 1976, after May 14); maximum on May 13, 1976; 45 counted in interior of Outer on May 6, 1976.
130. Water pipit Anthus spinoletta -- observed between May 21 (April 30, May 5) and May 28 (May 16), with a maximum of 6 on May 14, 1977; on south Outer and Presque Isle Beach.
131. Cedar waxwing Bombycilla cedrorum -- present May 20 (May 13, 20) on, migrating in small flocks.
132. Starling Sturnus vulgaris -- present throughout period, high count of 183 on May 1, 1977.
133. Yellow-throated vireo Vireo flavifrons -- in 1976, 3 on May 13 and 1 on May 19; in 1977, singles on May 10 and 13; all on south Outer.

134. Solitary vireo Vireo solitarius -- noted May 13 (May 11) through May 28 (May 23), maximum of 5 on May 25, 1976.
135. Red-eyed vireo Vireo olivaceus -- present May 27 (May 19, 24) on; almost immediately after arrival became one of commonest interior birds.
136. Philadelphia vireo Vireo philadelphicus -- 1 at Gray Dam May 29, 1976; 1 on south Devil's May 27, 1977.
137. Black and white warbler Mniotilta varia -- present May 8 (May 9) on; a total of 68 noted during morning counts in 1976, maximum of 6 on May 17 and 22.
138. Golden-winged warbler Vermivora chrysoptera -- 1 at South Beavers on May 25, 1976.
139. Tennessee warbler Vermivora peregrina -- observed between May 19 (May 12) and May 24 (May 28); day totals never exceeded 2.
140. Orange-crowned warbler Vermivora celata -- in 1976, 1 at north Outer May 9 and 4 at south Outer May 13; in 1977, 1 on south Outer May 12.
141. Nashville warbler Vermivora ruficapilla -- present May 9, 12 (May 8) on; frequented beaver clearings; a total of 62 noted in morning counts in 1976, maximum of 6 on May 20 and June 3.
142. Parula warbler Parula americana -- single birds noted on many days May 12 (May 10) on; a total of 21 found during 1976 morning counts.
143. Yellow warbler Dendroica petechia -- present May 19 (May 23) on; total of 26 noted on 1976 morning counts, maximum of 5 on May 27 and June 2; at South Pond and Presque Isle Bog.
144. Magnolia warbler Dendroica magnolia -- present May 12, 15 (May 10) on; total of 34 found during 1976 morning counts, maximum of 4 on May 28 and 29.
145. Cape May warbler Dendroica tigrina -- single birds noted on May 13, 15, 16, and 18, 1976 and on May 12, 1977; 2 found on May 22, 1976.
146. Black-throated blue warbler Dendroica caerulescens -- present May 15 (May 14) on, in Outer's interior, on Presque Isle Point, and once on Devil's; high count of 8 on Outer on June 1, 1976; total of 5 found on the 1976 morning counts.
147. Yellow-rumped warbler Dendroica coronata -- present April 28 (April 28) on; most abundant warbler until late May, with hundreds on south Outer on May 13, 1976; total of 123 noted on the 1976 morning counts.
148. Black-throated green warbler Dendroica virens -- present May 9 (May 1, 8) on; total of 59 noted during 1976 morning counts, maximum of 9 on May 29, 1976.

149. Blackburnian warbler Dendroica fusca -- first present May 11 (May 10), with a total of 15 noted during 1976 morning counts, maximum of 2 on 4 days.
150. *Chestnut-sided warbler Dendroica pensylvanica -- present May 12 (May 10) on, particularly at beaver clearings; total of 70 noted during 1976 morning counts, maximum of 8 on May 29.
151. Bay-breasted warbler Dendroica castanea -- 1 at Gorge Beavers on May 22, 1976; 1 on south Outer on May 19, 1977.
152. Blackpoll warbler Dendroica striata -- present May 18, 23 (May 13, 27) on; total of 8 recorded during 1976 morning counts, maximum of 2 on May 25.
153. Palm warbler Dendroica palmarum -- observed May 5 (May 1) to May 28 (May 20); peak numbers on May 13, 1976; total of 34 tallied on the 1976 morning counts.
154. Ovenbird Seiurus aurocapillus -- May 8, 12 (May 10) on, at many interior locations; total of 62 noted on 1976 morning counts, maximum of 8 on May 29.
155. Northern water-thrush Seiurus noveboracensis -- in 1976, observed at many wet locations May 13 to 27; total of 7 noted on 1976 morning counts, maximum of 2 on May 19; in 1977, only noted on May 30.
156. Connecticut warbler Oporornis agilis -- heard at beaver clearings on Outer on May 22 and 29, 1976, and on Devil's on May 28, 1977.
157. Mourning warbler Oporornis philadelphia -- present May 28 (May 27) on, maximum of 4 on June 3, 1976.
158. Yellowthroat Geothlypis trichas -- present May 13, 19 (May 17) on, primarily at bogs and beaver clearings; maximum of 9 on May 28, 1976; total of 38 recorded on 1976 morning counts.
159. Wilson's warbler Wilsonia pusilla -- present May 13, 14, 22 (May 16) on, primarily at beaver clearings and bogs; high count of 11 on May 28, 1977; total of 29 recorded on 1976 morning counts.
160. Canada warbler Wilsonia canadensis -- present May 20 (May 17) on, high count of 11 on June 3, 1976; total of 20 noted on 1976 morning counts.
161. American redstart Setophaga ruticilla -- May 14 (May 11) on; total of 67 noted on 1976 morning counts, maximum of 17 on May 28.
162. House sparrow Passer domesticus -- 1 at Outer light on May 4, 1976.
163. Bobolink Dolichonyx oryzivorus -- migrants present May 12 (May 16) through June 3 (May 28), noted primarily in flight; high count of 4 on May 26, 1976.

164. Eastern meadowlark Sturnella magna -- 2 on Presque Isle Bog on May 14, 1977.
165. Western meadowlark Sturnella neglecta -- 2 individuals noted in song on south Outer in 1976.

Meadowlark sp. -- occasionally noted throughout period, at Outer light, south Outer, Presque Isle Bog, and once at a beaver clearing; day totals never exceeded 2.
166. Yellow-headed blackbird Xanthocephalus xanthocephalus -- 1977 only, at south Outer, Presque Isle Bog and Beach, and once on Devil's; noted on 6 occasions May 10 to 28, maximum of 3 males and 1 female on May 23.
167. *Red-winged blackbird Agelaius phoeniceus -- present throughout period, high count of 68 on May 12, 1977.
168. Northern oriole Icterus galbula -- May 19 (May 10, 12) on, high count of 4 on May 27, 1977.
169. Rusty blackbird Euphagus carolinus -- noted April 28 (April 29) to May 13 (May 11), at north and south Outer and beaver clearings; high count of 15 on April 29, 1976.
170. Common grackle Quiscalus quiscula -- present throughout period in open areas, high count of 90 on May 1, 1977.
171. Brown-headed cowbird Molothrus ater -- common throughout period, high count of 504 on May 1, 1977.
172. Scarlet tanager Piranga olivacea -- small numbers present May 20 (May 11) on.
173. Rose-breasted grosbeak Pheucticus ludovicianus -- present May 13 (May 10) on, high count of 100 on May 13, 1977.
174. Indigo bunting Passerina cyanea -- noted between May 26 (May 11, 26) and May 28 (June 3), maximum of 2 on May 28, 1976 and May 27, 1977.
175. Evening grosbeak Hesperiphona vespertina -- in 1976, common through mid-May, less frequent after; in 1977, uncommon throughout period.
176. *Purple finch Carpodacus purpureus -- present throughout period, with a high count of 24 on April 29, 1976; less common in late weeks; adult feeding fledgling on June 3, 1976.
177. Pine grosbeak Pinicola enucleator -- single birds in flight over South Pond May 7 and 8, 1976.
178. Common redpoll Acanthis flammea -- single birds noted on April 30, May 4 and 6, 1976, at north and south Outer.
179. Pine siskin Spinus pinus -- present throughout period, but common only during early weeks of 1976; high count of about 150 on May 13, 1976.

180. American goldfinch Spinus tristis -- present May 14 (May 11) on.
181. Rufous-sided towhee Pipilo erythrophthalmus -- single birds on 8 days between May 13 (May 12) and June 3 (May 14).
182. Savannah sparrow Passerculus sandwichensis -- present in open areas in small numbers throughout period, maximum numbers at south Outer May 13, 1976.
183. Grasshopper sparrow Ammodramus savannarum -- 1 at Outer light May 17, 1976.
184. LeConte's sparrow Ammodramus leconteii -- single birds on May 13 and 28, 1976, and May 1, 10, and 24, 1977; at South Pond, Sand Point, and three times at wet spots in forested interior.
185. Henslow's sparrow Ammodramus henslowii -- 1 at Outer light on May 17, 1976.
186. Vesper sparrow Poocetes gramineus -- 1 at Outer light on May 14, 1976; at south Outer, 2 on May 19 and 1 on May 20, 1976.
187. Lark sparrow Chondestes grammacus -- 1 at Outer light on May 14, 1976.
188. Dark-eyed junco Junco hyemalis -- frequently noted in forest and clearings until mid-May; 1 at south Outer on May 28, 1976.
189. Tree sparrow Spizella arborea -- present through May 12, 19 (May 6); in open areas.
190. *Chipping sparrow Spizella passerina -- present May 9, 12 (April 30) on in open areas; maximum numbers on May 13, 1976, when many flocks left Outer for Stockton.
191. Clay-colored sparrow Spizella pallida -- present May 9, 13 (May 10) on, at south Outer, occasionally north Outer, and at Presque Isle Beach; maximum May 13, 1976.
192. Field sparrow Spizella pusilla -- 1 at south Outer on May 20, 1976.
193. Harris' sparrow Zonotrichia querula -- at south Outer, 6 on May 13 and 1 on May 20, 1976.
194. White-crowned sparrow Zonotrichia leucophrys -- present May 6 (May 8) through May 28 (May 24) in brushy areas; maximum May 13, 1976, when well over 100 were observed.
195. White-throated sparrow Zonotrichia albicollis -- present throughout period on all parts of the islands; common through mid-May, with maximum of over a thousand on May 13, 1976.
196. Lincoln's sparrow Melospiza lincolnii -- observed between May 20 (May 10) and May 27 (May 25), maximum of 3 on May 20, 1976.
197. *Swamp sparrow Melospiza georgiana -- present throughout period; maximum of 8 on April 29, 1976; bred at bogs, scarce elsewhere in last weeks.

198. *Song sparrow Melospiza melodia -- present throughout period, nesting in most clearings.
199. Lapland longspur Calcarius lapponicus -- single bird in winter male plumage at Sand Point from May 25 to 28, 1976.
200. Chestnut-collared longspur Calcarius ornatus -- lone male in breeding plumage on Sand Point May 27, 1976.
201. Snow bunting Plectrophenax nivalis -- observed between May 4 (April 28) and May 7 (May 10), maximum of 8 on April 29, 1977; at south Outer and twice at Outer light beach.