FISHERY RESOURCES OF THE ATHABASCA RIVER DOWNSTREAM OF FORT McMURRAY, ALBERTA

VOLUME I

by

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ABSTRACT

The fish populations of the Athabasca River downstream of Fort McMurray were sampled during the open-water period in 1976 and 1977. Fish were collected with gillnets, seines, and angling gear in order to identify the species present, to document their distribution and relative abundance, and to obtain samples for life history analysis. A conventional tagging program was undertaken to delineate migration patterns for the major fish species.

Twenty-seven fish species were identified from the Athabasca River, 11 of which were common. Species diversity was greatest near Fort McMurray, where all 27 species occurred, but decreased in a downstream direction, as only 18 species were captured in the Delta study area.

The Athabasca River and its tributaries provide important spawning, feeding, and rearing areas for a number of fish species and may play a major role in the maintenance of the fish populations of Lake Athabasca. Major upstream movements of walleye, goldeye, longnose suckers, and white suckers occur in the Athabasca River during early spring. These runs are initiated under ice-cover and reach the Mildred Lake study area before the ice leaves the Athabasca River. The walleye and sucker runs are spawning migrations and the early spring upstream movements of these species are followed by a more gradual downstream dispersal that continues throughout the summer. The entire lower Athabasca River serves as a summer feeding area for immature goldeye which enter the study area prior to break-up and leave in late autumn. These goldeye are thought to belong to the population that spawns in the Peace-Athabasca Delta. A large upstream spawning migration of lake whitefish occurs during September and October. Some whitefish return to Lake Athabasca shortly after spawning but others may overwinter in the Athabasca River. Trout-perch, flathead chub, emerald shiners, lake chub, and spottail shiners are the major forage fishes in the study area.

Floy tags were applied to 9311 fish during the study and the return rate to date is 4.2%. Results indicate that walleye,

goldeye, lake whitefish, longnose suckers, and white suckers found in the lower Athabasca River belong to populations that overwinter in Lake Athabasca and the Peace-Athabasca Delta.

The fry of many fish species appear in the Athabasca River during June and July. Most of these fry do not remain in the study area but are carried downstream to nursery areas in the lower Athabasca River or Lake Athabasca.

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1. INTRODUCTION

The possibility of disturbance to some lake and river systems of the lower Athabasca River drainage as a result of the present and proposed development of the Athabasca Oil Sands has raised concern as to the potential effect of such development on fish populations of the area.

Activities related to the mining of the oil sands as well as the increased urbanization of the area may be expected to affect the fishery in numerous ways. Blockage or diversion of streams may interfere with migrations, preventing fish from reaching traditional spawning and feeding areas. In some cases, such areas may be lost altogether. Activities in close proximity to streams may result in increased siltation with resultant increased mortality of eggs and fry (Griffiths and Walton 1978). Deterioration of water quality as a result of increased input of domestic wastes, herbicides, and other toxic materials may affect fish directly through increasing the mortality rates of adults, eggs, or fry, or indirectly by reducing the availability of food organisms (Machniak 1977; Lake and Rogers 1979; Costerton and Geesey 1979). Increased human population and improved access may result in over-exploitation of fish stocks and destruction of spawning and nursery areas. In most cases, the effect of such disturbances will be local (Jantzie 1977); however, in the case of migratory populations, e.g., from Lake Athabasca, these local effects may be manifested over a much wider area.

The fishery of the lower Athabasca drainage represents a valuable resource in terms of commercial, sport, and domestic usage. Because of this, the Alberta Oil Sands Environmental Research Program (AOSERP) initiated an integrated series of projects to assess the baseline state of the fishery resources in this area. The intent of these projects was to provide information that would enable minimization of the possible adverse effects of development on the fish populations of the Athabasca River and its tributary streams and to establish a data base against which future changes can be measured.

The present report summarizes the major findings of a two-year study of the fish fauna of the Athabasca River downstream of Fort McMurray, Alberta. Field work for the study was conducted during the summers of 1976 and 1977. The detailed results of the work are presented in two separate volumes (Bond and Berry in prep.a, in prep.b) to which the reader is referred.

Specific objectives for the present study were as follows:

1. To ascertain the seasonal distribution and relative abundance of the major fish species of the Athabasca River downstream from Fort McMurray;
2. To identify the migration patterns throughout the open-water period for these major fish species through a conventional tagging program;
3. To document the timing of the downstream movements of fry in the Athabasca River;
4. To identify possible spawning areas in the Athabasca River and in tributary streams through the presence of ripe and/or spawned-out fish as well as the presence of eggs and fry; and
5. To establish a data base with respect to the general biology of the major fish species that frequent the Athabasca River (i.e., age, growth, sex ratio, maturity, fecundity, food habits, etc.).

A further objective, that of defining the species composition and relative abundance of major fish species present in the Athabasca River under winter low-flow conditions, was not addressed owing to budgetary and time constraints.

2. RESUME OF CURRENT STATE OF KNOWLEDGE

A review by Jantzie (1977) concluded that, at the time the present study was initiated, the extent of the literature relative to the fisheries of the AOSERP study area was inadequate either for purposes of fishery management or as a baseline against which to measure the effects of oil sands development. Preliminary surveys conducted by the Alberta Fish and Wildlife Division had identified many of the fish species present in the AOSERP area and had provided some biological data on a few species (Turner 1968a, 1968b; Bradley 1969; Robertson 1970; Griffiths 1973). None of these studies dealt with fish populations of the Athabasca River proper. Studies related to the preparation of environmental assessments of oil sands leases 13 (Shell Canada Ltd.), 17 (Syncrude Canada Ltd.), and 30 (Home Oil Ltd.) increased our knowledge of the fish fauna of specific tributary streams. Although these studies (Lombard-North Group 1973; Renewable Resources Consulting Services Ltd. 1971, 1973, 1974a, 1974b, 1975) did not deal with the Athabasca River proper, they did document spawning migrations of some fish species into a few tributaries and implied a major role for the Athabasca River as a migration route to spawning areas.

Until recently, detailed study of fish populations of the Athabasca River was limited to the goldeye (Fernet 1971; Kooyman 1973; Donald and Kooyman 1974; Kristensen et al. 1976) and walleye (Bidgood 1968, 1971, 1973; Dietz 1973; Kristensen et al. 1976) populations of the Peace-Athabasca Delta. In the past few years, however, a number of projects, sponsored by both government and industry, have been conducted in the AOSERP area. These studies have added substantially to our knowledge of the fish populations of the Athabasca River and its tributaries within the AOSERP area.

Kristensen and Summers (1978), Kristensen (1978, 1979), and Summers (1978) have provided new data on the fish populations of the Peace-Athabasca Delta and Richardson Lake. McCart et al. (1977) have examined the fish populations of the Athabasca River in the vicinity of Syncrude lease 17. Jones et al. (1978) and Tripp and

McCart (in prep.) have pinpointed spawning areas for lake whitefish and longnose suckers, respectively, and provided data on other fish populations in the Athabasca and Clearwater rivers upstream of Fort McMurray. Recent studies on the Muskeg River (Bond and Machniak 1977, 1979), the Steepbank River (Machniak and Bond 1979), and the MacKay River (McCart et al. 1978; Machniak et al. in prep.) have provided a quantitative estimate of the significance of these tributaries in the regional context.

The present report provides a summary of the major findings of a two-year study on the fish populations of the Athabasca River downstream of Fort McMurray. The supportive data are presented by Bond and Berry (in prep.a, in prep.b).

3. DESCRIPTION OF THE STUDY AREA

The Athabasca River arises in the Rocky Mountains and flows approximately 1440 km before entering the western end of Lake Athabasca where it contributes to one of North America's major wetlands, the Peace-Athabasca Delta. Approximately 450 km of the river's course lie within the AOSERP study area (Figure 1), 300 km being downstream of Fort McMurray. The total drainage area of the Athabasca River is 156 928 km^2, about 25% of the surface area of Alberta. Approximately 17% of this area (26 880 km^2) is within the AOSERP study area. The long-term mean discharge of the Athabasca River at Fort McMurray is 645.7 m^3/s with the respective minimum and maximum recorded flows being 96.6 m^3/s and 4265.0 m^3/s (Kellerhals et al. 1972). Records obtained from the Water Survey of Canada (1977, 1978) showed a mean daily discharge at Fort McMurray of 679.7 m^3/s and 773.1 m^3/s in 1976 and 1977, respectively.

The portion of the Athabasca River studied in 1976 consisted of approximately 135 km of stream between the mouth of the Horse River, just upstream of Fort McMurray, and the mouth of the Firebag River (km 133.3)(Figure 1). The 1977 study was conducted in two general areas, each approximately 80 km in length. The upstream area, designated the Mildred Lake study area, extended from the mouth of Poplar Creek (km 27.2) to km 110.4, thus including most of the 1976 study area. The Delta study area included that portion of the Athabasca River between Embarras (km 190.4) and the mouth of Jackfish Creek (km 272.0)(Figure 1).

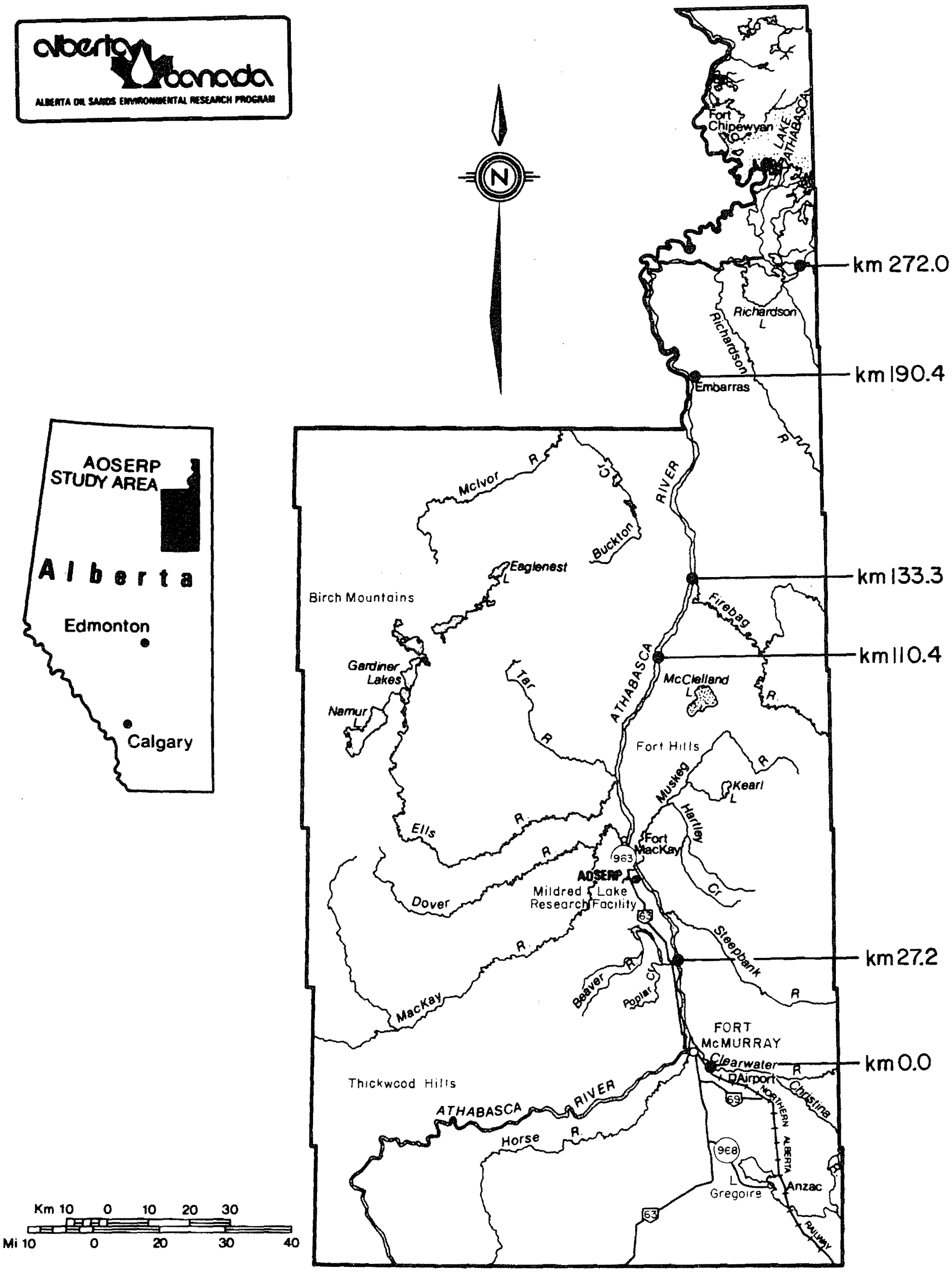

Figure 1. The AOSERP study area showing the project study area boundaries referred to in the text.

4. MATERIALS AND METHODS

4.1 FIELD AND LABORATORY TECHNIQUES

The fish populations of the Athabasca River were sampled during 1976 and 1977 using a variety of collection methods. Variable mesh gill nets (standard gangs), large mesh seines, and small mesh seines were the collection methods used most frequently, but angling gear and gill nets of various mesh sizes (tagging nets) were also used occasionally to acquire fish for tagging purposes. Complete descriptions of each gear type are given by Bond and Berry (in prep.a, in prep.b).

In 1976, field work was conducted from 4 May to 5 October, while in 1977, the sampling period extended from 17 April to 2 November, in the Mildred Lake study area, and from 15 May to 15 October, in the Delta study area. During the study, fish collections were made at many sites that could not be sampled regularly because they tended to disappear with fluctuating water levels. Other (major) sites, however, tended to be more permanent and were sampled at regular intervals. The locations of these major sampling sites have been identified by Bond and Berry (in prep.a, in prep. b).

Catch results from standard gangs, large mesh seines, and small mesh seines were analyzed separately for each sampling site by two-week periods. Results were expressed as absolute numbers and percentage frequency of occurrence for each species in each gear type. The catch-per-unit-effort for each species was expressed as the number of fish per standard gang per hour or as the number of fish per seine haul.

All fish from standard gangs and representative samples of fish from small mesh seines were subjected to complete biological analysis (Bond and Berry in prep.a, in prep.b). Biological data for each fish species were computerized and a general statistics program was run on them. The computer provided information on sex ratios, length-frequencies, length-weight relationships, and age and growth features. Food habits and fecundity were also evaluated for each species.

Movements of fish throughout the lower Athabasca River system were evaluated by means of a tagging program. Most fish for tagging were captured using large mesh beach seines but gill nets (tagging nets) and angling gear were also used for this purpose. Coded Floy anchor tags (Type FD - 68B) were utilized. The tagging program was well-publicized by posters and press releases, and a $2.00 reward was offered for returned tags. Tag returns were made by sport fishermen along the Athabasca River, by domestic fishermen on the Athabasca River and Lake Athabasca, and by commercial fishermen on Lake Athabasca. Personnel of LGL Ltd., Environmental Research Associates, Edmonton and Aquatic Environments Ltd., Calgary also returned tags.

4.2 LIMITATIONS OF METHODS

4.2.1 Fish Collection

The problems associated with sampling the fish populations of large rivers are well known and relate to conditions of current, fluctuating water levels, and water-borne debris. These conditions severely limit the choice of sampling sites as well as the efficiency of the gear employed.

Essentially, sampling sites used in this study were confined to areas in which the current was reduced to such a level as to permit the use of the gear. These, inevitably, were limited to inshore areas and catches made in such areas may not be truly representative of the overall situation.

In order to sample as great a variety of habitats as possible and to collect the greatest variety of fish, both in terms of size of individuals and number of species, it was necessary to employ a variety of collection methods, each of which has certain limitations. It is believed, however, that the combination of gillnets, large mesh seines, and small mesh seines has produced a reasonably good coverage of all species and all life history stages.

4.2.1.1 Standard gill net gangs. Gill nets are known to be highly selective for size of fish. Essentially, each mesh size tends to capture fish of a particular size range. This range varies with species and depends not only on the size of fish but on whether it is of a species that tends to be captured by wedging itself in a mesh (e.g., lake whitefish, flathead chub) or by entangling itself by teeth or spines (e.g., pike, walleye, goldeye). Fish captured by entangling usually demonstrate a wider size range in a particular mesh size.

Because of the limited size range over which a gill net of a given mesh size is effective, fish populations are best sampled by employing gangs of gill nets of varying mesh sizes whose selectivity curves overlap broadly. The standard gangs used in 1977 consisted of six mesh sizes and the catches produced are thought to be representative of the larger fish species. Similar gangs were considered effective for collecting most northern fish species by Rawson (1951) and Hatfield et al. (1972). This gang is believed to have eliminated much of the bias inherent in the standard gang of only three mesh sizes that was employed in 1976 (Bond and Berry in prep.a).

A feature of the 1976 standard gang that contributed to its inefficiency was its length (27.3 m). Since many of the sampling sites were not large enough to accommodate this entire gang, the offshore end often protruded into the main current where it became fouled with debris more quickly than the portion in the eddy. The shorter 1977 gang is thought to have performed better in this regard. Gill net efficiency is thought to have varied considerably with changes in river conditions. Generally, efficiency decreased during floods when debris tended to clog or damage the nets. Because such effects were not constant from site to site or throughout the summer, comparisons between sites are often meaningless. Because standard gangs were fished on the bottom, they may have tended to select for bottom dwellers (e.g., walleye) and to underestimate those that swim in mid-water or near the surface (e.g., goldeye).

4.2.1.2 Large mesh beach seines. These seines were found to be an extremely useful method of capturing fish for tagging. Using this gear, large numbers of fish could often be taken in a short period of time with minimal physical damage. They were effective for the same species and size of fish as were captured in standard gangs and retained all fish greater than about 200 mm fork length. Large mesh seines were effective under most river conditions; however, in the Delta study area, silt often clogged the bag, making seining difficult and reducing the efficiency of the operation. Large mesh seines complemented the standard gangs to a certain extent. Whereas the gill nets were fished only on the bottom, large mesh seines fished only the upper metre of the deeper eddies. No standard length or time of haul was employed for large mesh seines and the area seined by each haul did tend to vary somewhat as a result of differences in current or the presence of snags. Overall, however, hauls made with this gear possessed a high degree of uniformity.

4.2.1.3 Small mesh beach seines. These seines were effective for capturing small fish under a wide variety of conditions. They were difficult to use, however, in strong current, in deep water, or where rocks or logs interfered with the haul. Because of mesh limitations, these seines could not sample adequately the early life stages of most species. Few fish less than 20 mm in length were captured. Small mesh seine hauls were not standardized but, in fact, varied considerably in duration depending on the site. Thus, catch-per-unit-effort comparisons between sites may be meaningless. The average catch-per-unit-effort values produced in each sampling cycle, however, are believed to be fairly comparable and to provide a reasonable estimate of the relative abundance of the small fishes.

4.2.2 Age Determination and Growth Analysis

Scales are often used in determining the age of fish because these structures are easily acquired. The method assumes that the fish lays down one annulus on its scales per year and that such annuli can be identified. Such assumptions may not always be justified, however, especially in northern populations where the fish grow slowly and live for long periods of time. Beamish and Harvey (1969) demonstrated that age determinations by the scale method for white suckers in George Lake, Ontario were unreliable beyond the age of five years and recommended the use of pectoral fin rays. Craig and Poulin (1975) found that scales tended to underestimate the ages of older Arctic grayling in Alaska and recommended the use of otoliths for this species.

With the exception of suckers (fin rays) and burbot (otoliths), the larger fish in the present study were aged by the scale method. While this method may have underestimated the age of some of the older fish, scale ages appeared to be satisfactory for plotting reliable growth curves.

Growth curves were plotted using fish captured throughout the summer, a practice that tends to raise the mean length and weight of fish in a given age group and produce broad overlaps in the ranges for lengths and weights between age groups. Ideally, such comparisons should be made only between fish captured over a short period of time.

4.2.3 Tagging

The recapture of tagged fish can provide useful information concerning the extent and timing of fish movements. A degree of caution must usually be exercised, however, in the interpretation of the results. In the first place, one can never be absolutely certain that the movement exhibited by an individual fish is representative of all fish in the population. Secondly, since no tags will be recovered from areas where no fishing effort occurs, it can be argued that recaptures serve merely to identify fishing areas. As well, low recovery rates sometimes make it impossible to form firm conclusions as to general movement trends.

4.2.4 Winter Conditions

No winter sampling was conducted during the present study. As a result, no direct evidence has been acquired as to the existence or location of overwintering areas in the AOSERP study area.

5. RESULTS

5.1 GENERAL SUMMARY

1. The fish populations of the Athabasca River downstream from Fort McMurray were sampled during the open-water period in 1976 and 1977.
2. Twenty-seven species of fish, representing 10 families, occurred in the samples (Table 1). A greater species diversity was observed in the Mildred Lake study area (27 species) than in the Delta study area (18 species).
3. Using several collection methods, a total of 51 872 fish were captured during the study (Tables 2, 3, and 4). Eleven ("major") species were taken commonly and in large numbers while 16 species were uncommon or rare in the samples.
4. Floy tags were applied to 9311 fish of which 401 (4.3%) have been recaptured to date. The highest recapture rates were obtained for northern pike (10.2%), walleye (8.7%), and white suckers (8.2%)(Table 5).
5. The fish populations of the lower Athabasca River are highly migratory in nature and, among the major species, only northern pike, trout-perch, lake chub, and perhaps flathead chub appear to be year-round residents. However, the Athabasca River and its tributary streams provide spawning, feeding, and nursery areas for a number of species and function as migration routes between these sites and overwintering areas.
6. Early spring is the time of most intense fish movement in the Athabasca River, although a gradual, largely post-spawning movement occurs throughout the summer. Large runs of walleye, longnose suckers, white suckers, and goldeye, apparently from Lake Athabasca or the Peace-Athabasca delta, are initiated in early spring under ice-cover. These migrations reach the Mildred

Table 1. Scientific and common names of fish species captured in the Athabasca River during 1976 and 1977.

Family and Generic Names	Common Names	Where Captured	
		Mildred Lake Area	Delta Area
Family Salmonidae			
Salvelinus malma (Walbaum)	Dolly Varden	+[a]	
Coregonus clupeaformis (Mitchill)	Lake whitefish	+	+
Prosopium williamsoni (Girard)	Mountain whitefish	+	+
Thymallus arcticus (Pallas)	Arctic grayling	+	
Family Hiodontidae			
Hiodon alosoides (Rafinesque)	Goldeye	+	+
Family Esocidae			
Esox lucius Linnaeus	Northern pike	+	+
Family Cyprinidae			
Chrosomus eos Cope	Northern redbelly dace	+	
Chrosomus neogaeus (Cope)	Finescale dace	+	
Couesius plumbeus (Agassiz)	Lake chub	+	+
Hybognathus hankinsoni Hubbs	Brassy minnow	+	
Notropis atherinoides Rafinesque	Emerald shiner	+	+
Notropis hudsonius (Clinton)	Spottail shiner	+	+
Pimephales promelas Rafinesque	Fathead minnow	+	
Platygobio gracilis (Richardson)	Flathead chub	+	+
Rhinichthys cataractae (Valenciennes)	Longnose dace	+	+
Semotilus margarita (Cope)	Pearl dace	+	

continued ...

Table 1. Concluded.

Family and Generic Names	Common Names	Where Captured	
		Mildred Lake Area	Delta Area
Family Catostomidae			
Catostomus catostomus (Forster)	Longnose sucker	+	+
Catostomus commersoni (Lacépède	White sucher	+	+
Family Gadidae			
Lota lota (Linnaeus)	Burbot	+	+
Family Gasterosteidae			
Culaea inconstans (Kirtland)	Brook stickleback	+	+
Pungitius pungitius (Linnaeus)	Ninespine stickleback	+	+
Family Percopsidae			
Percopsis omiscomaycus (Walbaum)	Trout-perch	+	+
Family Percidae			
Perca flavescens (Mitchill)	Yellow perch	+	+
Stizostedion vitreum (Mitchill)	Walleye	+	+
Etheostoma exile (Girard)	Iowa darter	+	
Family Cottidae			
Cottus cognatus Richardson	Slimy sculpin	+	
Cottus ricei (Nelson)	Spoonhead sculpin	+	+

[a]+ indicates species captured.

Table 2. Number of fish[a] taken by each capture method during 1976.

Species	Number of Fish						% of Total
	Tagging Nets	Standard Gangs	Angling Gear	Large Mesh Seines	Small Mesh Seines	Total	
Goldeye	92	624	157	982	67	1 922	11.6
Walleye	437	174	179	40	368	1 198	7.2
Yellow perch	0	0	0	3	161	164	1.0
Northern pike	104	105	86	161	29	485	2.9
Lake whitefish	34	487	0	518	12	1 051	6.3
Mountain whitefish	1	1	0	0	9	11	0.1
Arctic grayling	0	4	0	5	8	17	0.1
Longnose sucker	187	46	0	6	ND	239	1.4
White sucker	52	12	0	40	ND	104	0.6
Sucker spp.	0	0	0	0	3 087	3 087	18.6
Trout-perch	0	0	0	3	5 360	5 363	32.4
Burbot	0	1	11	1	3	16	0.1
Flathead chub	27	92	34	128	162	443	2.7
Lake chub	0	0	0	0	978	978	5.9
Emerald shiner	0	0	0	0	1 059	1 059	6.4
Spottail shiner	0	0	0	0	316	316	1.9
Brassy minnow	0	0	0	0	19	19	0.1
Longnose dace	0	0	0	0	20	20	0.1
Pearl dace	0	0	0	0	1	1	<0.1
Finescale dace	0	0	0	0	2	2	<0.1
Iowa darter	0	0	0	0	1	1	<0.1
Fathead minnow	0	0	0	0	2	2	<0.1
Ninespine stickleback	0	0	0	0	2	2	<0.1

continued ...

Table 2. Concluded.

Species	Number of Fish: Tagging Nets	Standard Gangs	Angling Gear	Large Mesh Seines	Small Mesh Seines	Total	% of Total
Brook stickleback	0	0	0	0	2	2	<0.1
Slimy sculpin	0	0	0	0	21	21	0.1
Spoonhead sculpin	0	0	0	0	36	36	0.2
Total	934	1 546	467	1 887	11 725	16 559	

[a] Numbers are actual except for those shown for small mesh seines. In some cases, fish captured in a small mesh seine haul were only partially counted and then the total number was estimated.

Table 3. Number of fish[a] taken by each capture method from the Mildred Lake study area, 1977.

Species	Number of Fish: Tagging Nets	Standard Gangs	Angling Gear	Large Mesh Seines	Small Mesh Seines	Total	% of Total
Goldeye	103	475	0	852	28	1 458	9.1
Walleye	98	135	23	281	182	719	4.5
Yellow perch	0	0	0	1	212	213	1.3
Northern pike	68	56	32	201	59	416	2.6
Dolly Varden	0	1	0	0	0	1	<0.1
Lake whitefish	210	134	0	1 058	90	1 492	9.3
Mountain whitefish	2	1	0	0	3	6	<0.1
Arctic grayling	1	1	0	17	7	26	0.2
Longnose sucker	299	75	1	780	ND	1 155	7.2
White sucker	55	6	1	481	ND	543	3.4
Sucker spp.	0	0	0	0	5 312	5 312	33.2
Trout-perch	0	0	0	0	2 737	2 737	17.1
Burbot	8	4	9	16	16	53	0.3
Flathead chub	8	94	1	142	263	508	3.2
Lake chub	0	0	0	0	536	536	3.4
Emerald shiner	0	0	0	0	620	620	3.9
Spottail shiner	0	0	0	0	116	116	0.7
Longnose dace	0	0	0	0	26	26	0.2
Finescale dace	0	0	0	0	19	19	0.1
Northern redbelly dace	0	0	0	0	4	4	<0.1
Fathead minnow	0	0	0	0	13	13	0.1
Ninespine stickleback	0	0	0	0	2	2	<0.1
Brook stickleback	0	0	0	0	8	8	<0.1

continued ...

Table 3. Concluded.

Species	Number of Fish						% of Total
	Tagging Nets	Standard Gangs	Angling Gear	Large Mesh Seines	Small Mesh Seines	Total	
Slimy sculpin	0	0	0	0	13	13	0.1
Spoonhead sculpin	0	0	0	0	26	26	0.2
Totals	852	982	67	3 829	10 292	16 022	

[a] Numbers are actual except for those shown for small mesh seines. In some cases, fish captured in a small mesh seine haul were only partially counted and then the total number was estimated.

Table 4. Number of fish[a] taken by each capture method from the Delta study area, 1977.

Species	Number of Fish						% of Total
	Tagging Nets	Standard Gangs	Angling Gear	Large Mesh Seines	Small Mesh Seines	Total	
Goldeye	316	183	61	576	26	1 162	6.0
Walleye	78	114	8	80	80	360	1.9
Yellow perch	0	0	0	0	25	25	0.1
Northern pike	111	67	178	114	27	497	2.6
Lake whitefish	693	74	0	75	10	852	4.4
Mountain whitefish	0	0	0	0	1	1	<0.1
Longnose sucker	135	27	0	11	ND	173	0.9
White sucker	8	0	0	8	ND	16	0.1
Sucker spp.	0	0	0	0	788	788	4.1
Trout-perch	0	0	0	0	1 571	1 571	8.1
Burbot	2	0	0	1	74	77	0.4
Flathead chub	4	13	1	57	862	937	4.9
Lake chub	0	0	0	0	5	5	<0.1
Emerald shiner	0	0	0	0	12 191[b]	12 191	63.2
Spottail shiner	0	0	0	0	619	619	3.2
Longnose dace	0	0	0	0	1	1	<0.1
Ninespine stickleback	0	0	0	0	2	2	<0.1
Brook stickleback	0	0	0	0	1	1	<0.1
Spoonhead sculpin	0	0	0	0	13	13	0.1
Totals	1 347	478	248	922	16 296	19 291	

[a] Numbers are actual except for those shown for small mesh seines. In some cases, fish captured in a small mesh seine haul were only partially counted and then the total number was estimated.

[b] An estimated 10 000 emerald shiner were taken in a single seine haul on 6 September 1977.

Table 5. Summary of tagging and recapture information for fish tagged in the Athabasca River in 1976 and 1977.

Species	Tag Releases			Tag Recaptures[a]	
	1976	1977	Total	Number	Percent
Goldeye	1123	1912	3035	66	2.2
Lake whitefish	464	1925	2389	70	2.9
Longnose sucker	103	1164	1267	35	2.8
Walleye	434	525	959	83	8.7
Northern pike	282	657	939	96	10.2
White sucker	77	506	583	48	8.2
Flathead chub	32	46	78	2	2.6
Burbot	13	35	48	1	2.1
Arctic grayling	0	13	13	0	0.0
Total	2528	6783	9311	401	4.3

[a] Includes tags returned as of 30 November 1979.

Lake study area before the ice leaves the Athabasca River. The walleye and sucker migrations are pre-spawning movements. The goldeye migration, on the other hand, represents a movement to a summer feeding area that extends from Lake Athabasca to Fort McMurray and probably beyond. These goldeye, which are virtually all immature fish, are thought to be part of the goldeye population that spawns in the Peace-Athabasca Delta.

7. Arctic grayling are seldom taken in the Athabasca River during the summer. These fish leave the Athabasca River in late April and early May to spawn and feed in tributaries such as the Muskeg and Steepbank rivers. Grayling remain in the tributaries until just prior to freeze-up when they return to overwintering areas suspected to be in the Athabasca River.
8. A large migration of lake whitefish from Lake Athabasca begins in early September and passes through the Mildred Lake study area in late September and early October en route to spawning areas located upstream of Fort McMurray in the Athabasca River. Some of these fish return to the lake shortly after spawning but others may overwinter in the Mildred Lake study area.
9. The presence of large burbot in the Mildred Lake study area in early spring and the appearance of fry in June suggest spawning by burbot in or upstream of the Mildred Lake study area.
10. This study located no actual spawning sites in the Athabasca River, either in the Delta study area or in the Mildred Lake study area. However, on the basis of catch and maturity data, the time of appearance of young-of-the-year, information from other studies in the area, and a knowledge of the spawning requirements of the various species, it is possible to make fairly

reliable judgements about spawning areas and times. This, and other information relative to the major fish species of the Athabasca River, is presented in Table 6.

With the exception of northern pike (which probably spawn in marshy areas throughout both study areas), spottail shiners, and perhaps trout-perch, no fish are believed to utilize the Delta study area of the Athabasca River for spawning purposes. The unstable substrate of sand and silt that is predominant in the delta does not provide suitable spawning habitat for most of the fish species of the AOSERP study area. Walleye from Lake Athabasca are known to spawn, however, in Richardson Lake (Bidgood 1968, 1971, 1973; Summers 1978).

Spawning areas for walleye, flathead chub, emerald shiners, and possibly lake chub are believed to be located in the Athabasca River within or upstream of the Mildred Lake study area. Lake whitefish, the only fall spawners among the major species, are known to spawn in the rapids area of the Athabasca River upstream of Fort McMurray (Jones et al. 1978). Burbot apparently spawn in the Clearwater River (Tripp and McCart in prep.).

Longnose suckers, white suckers, Arctic grayling, trout-perch, and perhaps lake chub are known to spawn in the lower reaches of tributaries that enter the Athabasca River in the Mildred Lake study area. Important spawning streams include the Muskeg, Steepbank, and MacKay rivers. Longnose suckers are also known to spawn in the rapids area of the Athabasca River upstream of Fort McMurray (Tripp and McCart in prep.).

11. The fry of many fish species appear in the Athabasca River during June and July. Most do not remain in the

Table 6. Summary of important results relative to the major fish species of the Athabasca River.

Species	Migrations	Spawning	Overwintering	Principal Foods	Predators	Competitors	Sensitive Locations and Times	Use by Man Within AOSERP Area
Goldeye	Feeding migration into Athabasca R. occurs in early spring (April) under ice. All immature fish (ages 4 to 6). Leave feeding grounds in Sept. or Oct. for overwintering areas.	N/A As adults these fish will probably spawn in Peace-Athabasca delta.	Suspected in Lake Athabasca or the Peace River.	Benthic and surface insects.	Pike, Walleye, Burbot	Few, because of varied diet.	Entire Athabasca R. up to (and probably beyond) Fort McMurray serves as summer feeding area from April to October.	Commercial Domestic Sport
Lake Whitefish	Spawning migration Sept. to Oct. Post-spawning downstream movement begins immediately after spawning. Downstream fry migration probably April to June.	Mid-Oct. in Athabasca R. upstream of Fort McMurray (Cascade and Mountain Rapids).	Most likely in Lake Athabasca. Some overwintering suspected in Mildred Lake study area.	Benthic invertebrates.	Pike, Walleye, Burbot	Bottom feeders, White Suckers, Longnose Suckers	Tributary mouths serve as resting areas during spawning migration. Egg incubation Nov. to March.	Domestic
Longnose Sucker	Spawning migration begins under ice in late April to early May. Post-spawning, downstream movement begins in mid-May. Fry emerge late May to early June. Fry migration June to August. Some non-spawners remain in tributaries until freeze-up.	Over gravel in tributaries during first half of May. Muskeg R., Steepbank R., MacKay R. are known spawning streams. Also spawn in Athabasca R. upstream of Fort McMurray.	Probably Lake Athabasca. Some young-of-year overwinter in spawning streams.	Benthic invertebrates but feed little during spawning migration.	Pike, Walleye, Burbot, Grayling, Flathead Chub	Bottom feeders, Lake Whitefish, White Suckers	Athabasca R. during migration of adults and dry (April to August). Spawning and nursery areas in tributaries (May to July). Mouth areas of tributaries are important nursery areas.	Domestic (Dog Food)
Walleye	Spawning migration begins under ice in late April. Post-spawning downstream movement in May and June. Fry hatch in May to June and migrate downstream during June and July.	Sites unknown but probably in Athabasca R. upstream of Fort McMurray in late April and early May.	Suspected in Lake Athabasca.	Mainly fish of several species. Some aquatic insects.	Pike, Burbot, Walleye	Pike, Burbot	Athabasca R. during migration of adults and fry. Tributary mouths serve as resting areas for adults and as nursery areas.	Commercial Domestic Sport
Northern Pike	Spawning movements in April and early May. Upstream migrations noted in some tributaries in May consist of ripe, spent and immature fish. Frequent lower reaches and mouth areas of tributaries during summer.	Probably late April and early May in marshy areas adjacent Athabasca R. and in some tributaries.	Probably Athabasca R. in Mildred Lake area. Those in Delta may overwinter in Athabasca R. upstream of Delta or in Lake Athabasca.	Mainly fish of several species. Some immature insects.	Pike, Burbot, Walleye	Walleye, Burbot	Marshy areas in late April and early May. Lower reaches of tributaries important feeding areas in summer.	Sport Domestic
White Sucker	Spawning migration begins under ice in late April to early May. Downstream movement of spawners begins in mid-May. Fry emerge late May and early June. Fry migration June to August. Some non-spawners remain in tributaries until freeze-up.	Over gravel in tributaries during first half of May. Muskeg R., Steepbank R., MacKay R. are known spawning streams.	Probably Lake Athabasca. Some young-of-year overwinter in spawning streams.	Benthic invertebrates but feed little during spawning period.	Pike, Burbot, Grayling, Flathead Chub	Bottom feeders, Lake Whitefish, Longnose Suckers	Athabasca R. during migration of adults and fry. Spawning and nursery areas in tributaries (May to July). Mouth areas of tributaries are important nursery areas.	Domestic (Dog Food)
Flathead Chub	May be resident in Athabasca R. Mature fish more common in Mildred than in Delta study area. Decrease in abundance after June suggests movement but extent unknown. Seldom enter tributaries. Young-of-year appear in July. Nursery areas suspected in Delta or Lake Athabasca.	Areas unknown but assumed in Athabasca R. within or upstream of Mildred Lake area during June and July.	Unknown. Suspected within Athabasca R. and Lake Athabasca.	Varied. Mainly mature and immature insects, both aquatic and terrestrial.	Pike, Walleye, Goldeye, Burbot	Few, because of varied diet.	Spawning and egg incubation probably in Athabasca R. from mid-June to mid-August.	None but sometimes taken by anglers.

continued ...

Table 6. Concluded.

Species	Migrations	Spawning	Overwintering	Principal Foods	Predators	Competitors	Sensitive Locations and Times	Use by Man Within AOSERP Area
Emerald Shiner	Spawning migration into Mildred Study area assumed in May and June. Seldom enter tritubaries. Most spawners age 2. Large post-spawning mortality suspected. Fry migrate downstream during summer and remain in Delta and/or Lake Athabasca until age 2.	Areas unknown but assumed in Athabasca R. within or upstream of Mildred Lake area. Probably spawn in June and July.	Suspected in Delta and/or Lake Athabasca.	Benthic invertebrates (Mostly insects).	Walleye, Pike, Goldeye, Burbot		Spawning and egg incubation in Athabasca R. during June and July.	None
Trout-perch	Probably resident in Athabasca R. Enter tributaries in May to spawn during Late May or eafly June. Severe post-spawning mortality suspected. Fry emerge in early June and migrate out of tributaries to Athabasca R. during June and July.	Tributaries in lake May and early June. Possibly Athabasca R. also.	Probably Athabasca R.	Benthic invertebrates (Mostly insects).	Walleye, Pike, Goldeye, Burbot		Spawning and egg incubation in tributaries from May to July.	None
Lake Chub	Seldom found in Delta but common in Lildred Lake study area and in tributaries. Fry appear in Athabasca R. in July. Few matures captured.	Locations unknown. Probably spawn in lower reaches of tributaries or along edge of Athabasca R. in Mildred Lake area during May or June.	Athabasca R. or tributaries in Mildred Lake study area.	Benthic invertebrates. (Mostly insects).	Walleye, Pike, Goldeye, Burbot		Probably spawn in May or June.	None
Spottail Shiner	Occur throughout study area but more common in Delta study area. Fry appear mid-July but not abundant until mid-August. Seldom enter tributaries.	Unknown but probably Athabasca R. or lower reaches of some tributaries in late June or early July.	Probably Athabasca R. and Lake Athabasca.	Benthic invertebrates (Mostly insects).	Walleye, Pike, Goldeye, Burbot		Spawning and egg incubation in late June or early July.	None
Arctic Grayling	Migrate into tributary streams of Mildred Lake area in late April and early May. Seldom found in Athabasca R. during summer. Never taken in Delta. Migrate out of tributaries just prior to freeze-up in October. Tributaries provide summer feeding for adults and nursery areas for fry.	Late April and early May. Muskeg R. and Steepbank R. are known spawning streams.	Young-of-year may overwinter in spawning streams. Age 1+ and older fish overwinter in Athabasca R. probably in upper Mildred area or above Fort McMurray.	Mature and immature stages of aquatic and terrestrial insects.	Walleye, Pike, but probably little predation while in tributaries.	Few, because of varied diet.	Spawning, feeding, and nursery areas in tributaries. Overwintering areas for young in tributaries. Susceptible to overharvest by anglers.	Sport
Burbot	A spawning migration into Mildred Lake area is suspected during the winter. Burbot leave Mildred area by mid-June. Young-of-year appear early June.	Spawning for this species usually occurs from Jan. to March under ice.	Probably Lake Athabasca.	Fish of many species	Walleye, Pike	Walleye, Pike, Goldeye	Spawning and egg incubation in or upstream of Mildred Lake area Jan. to June.	Domestic Sport

system but are carried by the current to the delta or Lake Athabasca. Back water areas in tributaries, as well as tributary mouths, provide important nursery areas for these small fish.

12. The present study gathered no information regarding the winter ecology of any fish species within the AOSERP study area.

5.2 SUMMARIES FOR MAJOR FISH SPECIES

Within the project study area, 11 fish species occur commonly and in large numbers during the open-water period. Life history details for these "major" species are summarized in the following sections.

5.2.1 Goldeye

5.2.1.1 Distribution and relative abundance. Among the large fish (those susceptible to capture by gill nets, large mesh seines, and angling), goldeye was the most abundant species captured during the study. This species accounted for 33% of all fish taken by these gear types over two years and was captured at virtually all sampling locations. Goldeye were abundant in the Mildred Lake study area at the time of ice break-up (late April) in 1977. Catch-per-unit-effort values were generally highest during April and May (Figure 2) but goldeye remained very common in both study areas throughout the summer. Catch-per-unit-effort decreased in September and few goldeye were captured in October, indicating that they had left the study area.

5.2.1.2 Age and growth. Athabasca River goldeye ranged in fork length from 24 to 409 mm with young-of-the-year varying from 24 to 55 mm. In 1976, 94% of all goldeye captured were between 230 and 299 mm with 3% exceeding 299 mm in fork length. Goldeye taken in 1977 were slightly larger than those captured the previous year.

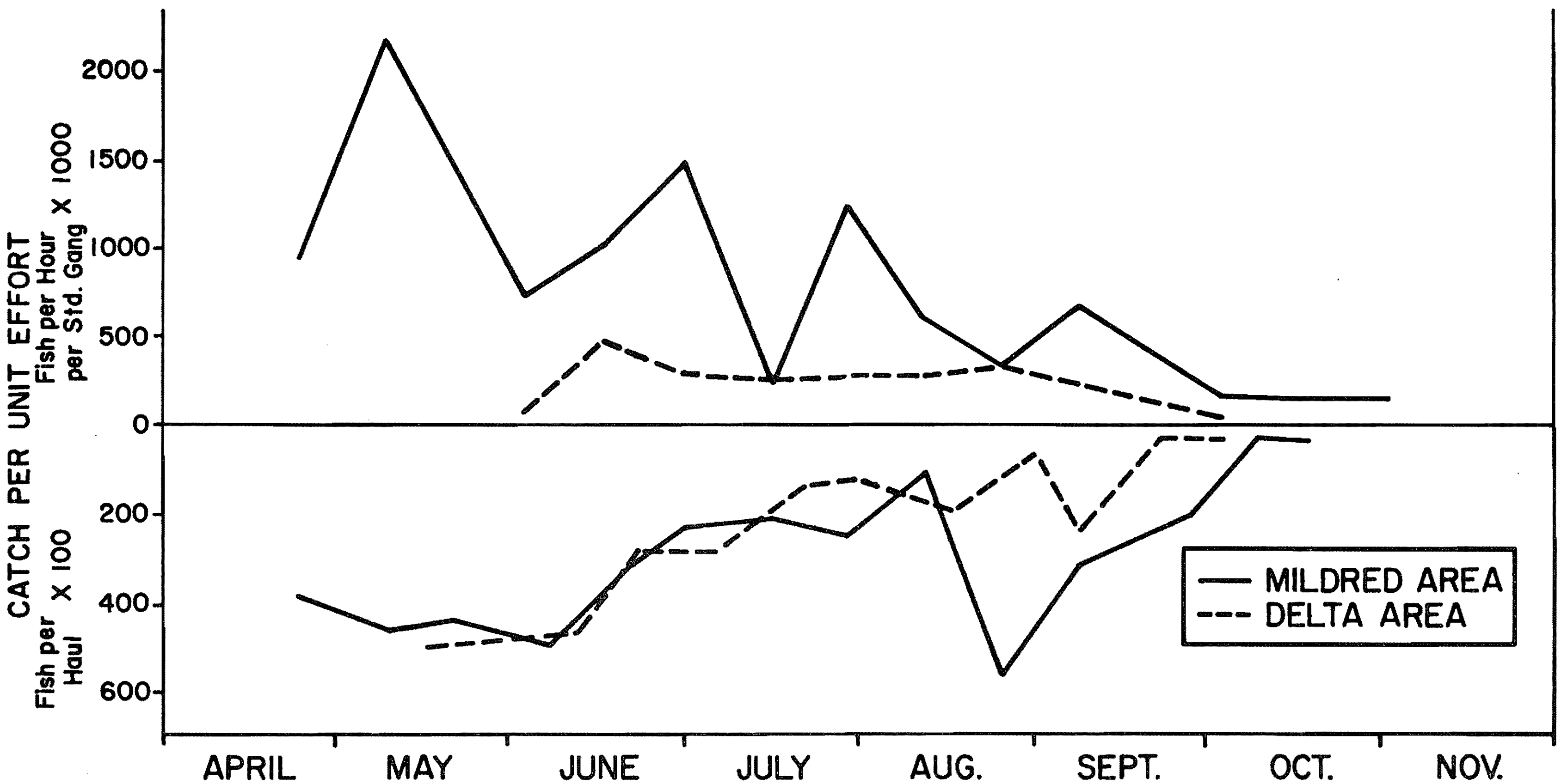

Figure 2. Seasonal changes in catch-per-unit-effort for goldeye captured in standard gangs and large mesh seines in the Mildred Lake and Delta study areas of the Athabasca River, 1977.

During the second year of the study, 84% of the goldeye taken were between 230 and 299 mm while 12% of the sample exceeded this length.

Age determinations were performed for 506 goldeye captured in 1976 and for 713 goldeye taken during 1977. Overall, scale ages ranged from 0+ to 9 years. The 1977 sample consisted principally of age 4 (13%), age 5 (33%), and age 6 (42%) fish which correspond to the 1973, 1972, and 1971 year classes, respectively. The 1971 and 1972 year classes were also well represented in 1976 when they were captured as four- and five-year-old fish and accounted for 53% and 40% of the sample, respectively.

Kennedy and Sprules (1967) reported that, among older goldeye, females tended to be larger than males of equal age. Although few old goldeye were captured during the present study, the available data suggest that this is true for goldeye in the lower Athabasca River with the divergence in growth rates occurring at age 5 or 6. Female goldeye captured in the Mildred Lake study area in 1977 were significantly larger than males ($P < 0.05$), both in fork length and weight, at ages 5 and 6. Males from the Delta study area were larger than females at age 4, no difference occurred at age 5, and at age 6, females were significantly larger than males ($P < 0.05$).

5.2.1.3 Sex and maturity. Approximately 99% of all goldeye examined were sexually immature and no ripe fish were captured during the study. Males and females were present in approximately equal numbers during 1976 and this equality extended to most age classes in 1977. However, in 1977, females outnumbered males by a wide margin in age group 6. Females accounted for 68% of six-year-old goldeye in the Mildred Lake study area and made up 79% of this age group in the Delta sample. The reduction in the number of males in age group 6 is believed to reflect the earlier age at which sexual maturity is first achieved by male goldeye. According to Scott and Crossman (1973), male goldeye in the Peace-Athabasca Delta begin to mature at age 6 while females do not spawn until age 7.

5.2.1.4 Spawning. Thirty-three young-of-the-year goldeye were captured during the study, of which 20 were found in the Delta study area. The paucity of young goldeye, plus the fact that few mature fish were taken, indicates that no goldeye spawning areas of any significance occur within the study area. Major goldeye spawning areas do occur, however, within the Peace-Athabasca Delta and it is believed that the immature goldeye found in the lower Athabasca River during the summer are pre-spawning members of the population that spawns either in the delta or in Lake Athabasca itself.

5.2.1.5 Migrations and movements. Goldeye have been reported to undergo extensive migrations, often travelling considerable distances in short periods of time (Reed 1962; Donald and Kooyman 1977). Catch-per-unit-effort data gathered during the present study (Figure 2) indicate that goldeye migrate into the lower Athabasca River in the early spring and leave again in late summer or autumn to return to overwintering areas in Lake Athabasca, the Peace-Athabasca Delta, or the Peace River. Goldeye entered the Mildred Lake study area before or during the spring break-up. This migration consisted almost exclusively of immature fish and represented a movement to summer feeding grounds. Higher catch-per-unit-effort values recorded in April and May than subsequently indicate that the upstream movement continued for some distance beyond the Mildred Lake study area. Jones et al. (1978) stated that the upstream movement may extend as far as Grand Rapids on the Athabasca River (140 km above Fort McMurray) and at least 8 km upstream in the Clearwater River.

Evidence from tag returns suggests that the goldeye found in the project study area during the summer belong to the same population that spawns in the Peace-Athabasca delta. Goldeye tagged in the Mildred Lake and Delta study area have been recaptured in Lake Athabasca (N = 7), at Chenal des Quatre Fourches (N = 5), at Revillon Coupé (N = 1), and near Peace Point, 257 km upstream in the Peace River (N = 1). In addition, one goldeye tagged in the Peace-Athabasca Delta by personnel of LGL Ltd., was recaptured in the

Athabasca River, 75 km north of Fort McMurray. The greatest movement recorded for a goldeye in this study was 320 km for a fish tagged 31 July 1976, 35 km north of Fort McMurray, and recaptured 19 September 1976 at Revillon Coupé, north of Fort Chipewyan (Figure 1).

Although goldeye move long distances within the lower Athabasca River system during their spring and fall migrations, tag return evidence indicates that movement is generally restricted during the summer when the fish are on their feeding grounds.

5.2.1.6 Food habits. Analysis of stomach samples collected in 1976 showed goldeye to have consumed a wide variety of food items. Included in the diet were mature and immature stages of both aquatic and terrestrial insects, fish, frogs, mice, and plant material. However, insects comprised the bulk of the food with Plecoptera and Ephemeroptera nymphs and Hymenoptera and Hemiptera adults being the food items most frequently eaten.

The diet of goldeye varied throughout the summer. During May and June, Plecoptera nymphs formed the bulk of the diet with Ephemeroptera and Hymenoptera becoming more important in July and August. Adult Hemiptera (Corixidae) dominated the stomach contents in September and October.

5.2.2 Lake Whitefish

5.2.2.1 Distribution and relative abundance. Lake whitefish were second in abundance among the large fish species taken during the study. This species comprised 24% of all fish captured by gill nets, large mesh seines, and angling over the two years.

Few lake whitefish were captured between May and mid-August, either in the Mildred Lake or Delta study area, but catch-per-unit-effort increased rapidly in late August and early September (Figure 3) with the commencement of a large spawning migration. The peak of the spawning run passed the Delta study area on 6 September in 1977, approximately two to three weeks prior to its arrival in the Mildred

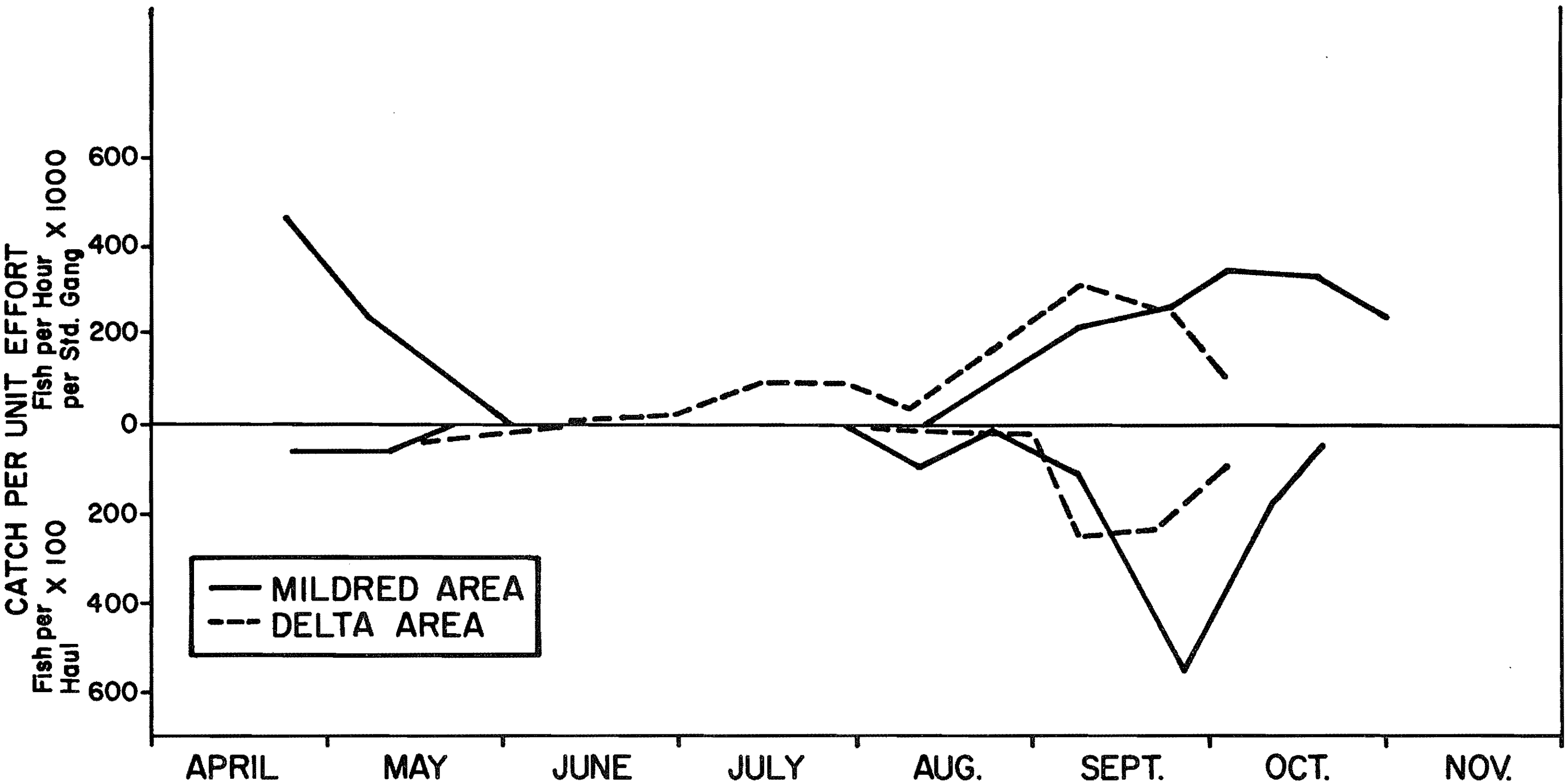

Figure 3. Seasonal changes in catch-per-unit-effort for lake whitefish captured in standard gangs and large mesh seines in the Mildred Lake and Delta study areas of the Athabasca River, 1977.

Lake study area. The timing of the upstream run was similar in both years of the study.

During the upstream migration, large numbers of lake whitefish were often taken in back eddies and in the mouths of larger tributaries, indicating that such areas are important to lake whitefish as staging and resting areas at this time of year.

The abundance peak observed in late April and early May 1977 (Figure 3) suggests that some lake whitefish may overwinter in the Mildred Lake study area.

Young-of-the-year lake whitefish apparently spend little time within the study area after hatching as few were captured. Most of the fry captured were taken in the Mildred Lake study area in mid-June.

5.2.2.2 Age and growth. Lake whitefish ranged from 22 to 539 mm in fork length. Young-of-the-year varied in length from 22 to 130 mm while, of the older fish, 90% were between 340 and 449 mm.

Age determinations, carried out on 517 lake whitefish captured in 1976 and 192 taken during 1977, showed scale ages to range from 0+ to 13 years with age groups 4 to 8 inclusive comprising 92% of the total sample.

Male and female lake whitefish grew at the same rate in terms of fork length. While females tended to be heavier than males of equal age, such differences were seldom statistically significant.

5.2.2.3 Sex and maturity. The vast majority of lake whitefish examined ($>95\%$) were sexually mature. This high percentage results from the fact that few whitefish were captured other than during the fall spawning run and indicates that few immature fish participate in the migration. While some lake whitefish of both sexes appear to mature at age 3, most do not spawn until age 4, at which age 96% of the fish examined were sexually mature.

5.2.2.4 Spawning. Ripe lake whitefish were not captured in the Delta study area in 1977. In the Mildred Lake study area, ripe females were not captured until 18 October and fully ripe males were never captured. Spent lake whitefish were taken in the Mildred Lake study area from 24 October to 2 November.

Spawning of lake whitefish was not observed during the present study and it is unknown whether, or to what extent, this event occurs within the Mildred Lake study area. However, Jones et al. (1978) reported that, in 1977, lake whitefish spawned below Mountain Rapids and Cascade Rapids in the Athabasca River, 15 and 32 km, respectively, upstream of Fort McMurray. Spawning occurred between 13 and 25 October at water temperatures ranging from 6° to 3°C.

5.2.2.5 Fecundity. The estimated fecundity for 13 mature female lake whitefish [382 to 473 mm fork length (F.L.)], captured in the Mildred Lake study area on 4 and 5 October 1977, ranged from 13 906 to 44 058 with a mean of 22 815 ova per female.

5.2.2.6 Migrations and movements. Catch-per-unit-effort values indicated that a large lake whitefish spawning migration occurred in the Athabasca River during both years of the study. In 1977, the peak of the migration passed the Delta study area on 6 September (Figure 3), at which time Athabasca River water temperature was near 14°C. The migration reached the Mildred Lake study area between 20 September and 5 October, by which time water temperatures were between 11° and 6°C.

Jones et al. (1978), working on the Athabasca and Clearwater rivers upstream of Fort McMurray, reported that concentrations of lake whitefish entered the Athabasca River portion of their study area during the first two weeks of October and that spawning occurred below Mountain Rapids and Cascade Rapids between 13 and 25 October. They captured no lake whitefish upstream of Cascade Rapids indicating that this was the upstream limit of the migration. No ripe whitefish were taken in the Clearwater River. These authors also reported that whitefish had begun to leave the spawning grounds by 20 October and that none was captured after 26 October.

Between 24 October and 2 November 1977, spent lake whitefish of both sexes were captured in the Mildred Lake study area as they began their post-spawning, downstream movement. Evidence from tag returns indicates that some lake whitefish undertake a rapid downstream movement to Lake Athabasca and the Peace-Athabasca Delta soon after spawning. However, the presence of lake whitefish in the Mildred Lake study area during April and early May (Figure 3) suggests that considerable numbers may overwinter within the Athabasca River.

5.2.2.7 Food habits. Stomachs of lake whitefish captured between 20 May and 8 September 1976 (N = 123) contained little food, with 87% of all stomachs being empty. Most fish (63%) captured in late September and early October contained some food. Aquatic insects made up 93% of the total food volume with Hemiptera accounting for 83%.

5.2.3 Walleye

5.2.3.1 Distribution and relative abundance. Walleye comprised 12% of all fish captured by gill nets, large mesh seines, and angling gear, ranking third in abundance among species captured by these gear types.

Walleye were captured in large numbers in the Mildred Lake study area during late April and early May 1977. After mid-May, catch-per-unit-effort decreased but walleye continued to be captured in both study areas throughout the open-water period (Figure 4). The 1976 results indicated a similar trend.

Young-of-the-year walleye first appeared in the Mildred Lake study area in mid-June. During late June and July, walleye fry occurred in considerable numbers in this area but catch-per-unit-effort decreased in late summer.

Although young-of-the-year walleye were not captured in large numbers in the Delta study area, they appeared to be numerous there in mid-June. These young fish probably originated from spawning

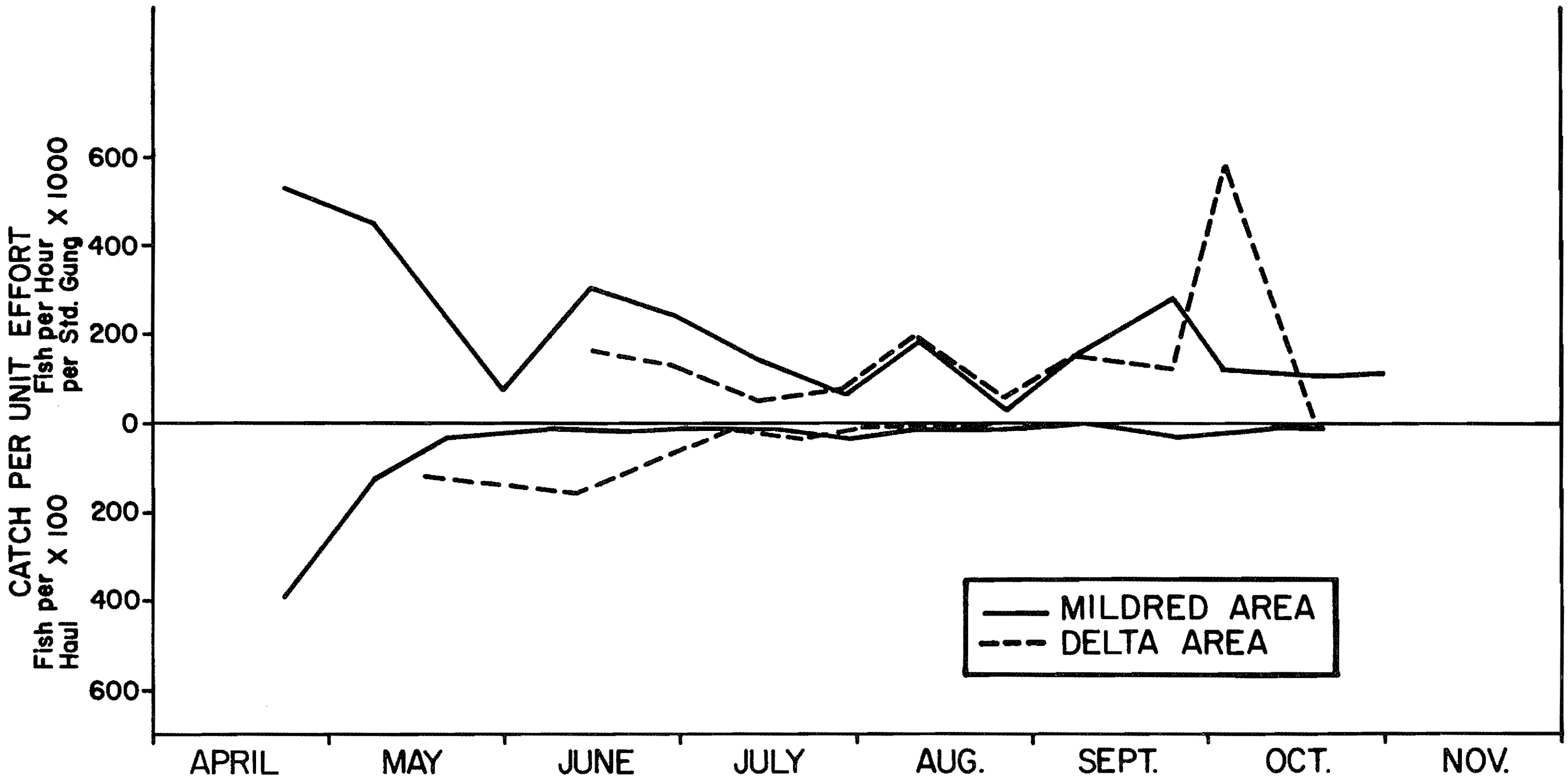

Figure 4. Seasonal changes in catch-per-unit-effort for walleye captured in standard gangs and large mesh seines in the Mildred Lake and Delta study areas of the Athabasca River, 1977.

areas within the delta (e.g., Richardson Lake) as well as from upstream sites.

5.2.3.2 Age and growth. Walleye captured during the study varied in fork length from 22 to 729 mm, with young-of-the-year ranging from 22 to 115 mm. Exclusive of young-of-the-year, the majority of walleye (82%) were between 300 and 499 mm long.

Age determinations were performed on 591 walleye older than young-of-the-year. The oldest scale age obtained was 13 years; however, in 1976, 90% of the sample were age 3 to 7 inclusive while in 1977, most walleye (85%) were age 4 to 8 inclusive.

Female walleye tended to be larger than males of the same age both in fork length and weight. Significant differences between the means ($P < 0.05$) occurred most often in age groups 6 to 8 inclusive.

5.2.3.3 Sex and maturity. Male walleye in the Athabasca River achieve sexual maturity at an earlier age than do females. In the present study, the youngest mature male was age 3 and virtually all males were mature by age 4. Females may mature as early as age 4 but most do not reach maturity until age 5 or 6.

Sex ratios observed for walleye during the study fluctuated greatly, emphasizing the difficulty in obtaining representative data from a migrant population. Males tended to outnumber females with the greatest differences occurring in the Mildred Lake study area and early in the year. During 1976, males made up 81% of all walleye sampled. In May, 97% of walleye were males while from July to October, males accounted for 64% of all walleye captured. In the 1977 study, males made up 63% and 57% of all walleye in the Mildred Lake and Delta study areas, respectively.

5.2.3.4 Spawning. Walleye spawning was not observed during the study. The results indicate, however, that ripe walleye enter the Mildred Lake study area under the ice and that spawning may commence before break-up. In 1977, ripe males were captured on 22 April and spent females were taken as early as 1 May. Young-of-the-year had a mean fork length of 34.7 mm (range 24 to 56 mm) by 28 June, indicating that considerable growth had occurred by that date. A post-spawning movement of spent males into the Steepbank River between 2 and 28 May 1977 (Machniak and Bond 1979) suggests that spawning had terminated by that time.

Within the AOSERP study area, the most likely walleye spawning grounds appear to be the bouldery areas of the Clearwater and Athabasca rivers upstream from Fort McMurray. It is possible, however, that some spawning takes place in the upstream parts of the Mildred Lake study area. Walleye do not appear to utilize the tributaries of the Mildred Lake study area for spawning purposes (Bond and Machniak 1977, 1979; Machniak and Bond 1979; Machniak et al. in prep.), although young-of-the-year have been captured in the lower reaches of the Steepbank, MacKay, and Ells rivers (Bond and Berry in prep.a). Walleye spawning is known to occur in Richardson Lake (Figure 1); however, it is doubtful that spawning occurs in the Delta study area portion of the Athabasca River.

5.2.3.5 Fecundity. Fecundity estimates for six mature female walleye (473 to 613 mm F.L.), captured in the Mildred Lake study area between 29 April and 4 May 1977, varied from 39 466 to 117 588 with a mean of 79 970 eggs per female.

5.2.3.6 Migrations and movements. Walleye, en route to spawning areas, enter the Mildred Lake study area in the spring before the ice leaves the Athabasca River. The paucity of females in May and June samples may indicate that females leave the area immediately after spawning. Males, on the other hand, tend to linger in the Mildred Lake study area, sometimes moving into tributaries. Post-spawning migrations of spent male walleye have been observed in the Steepbank River (Machniak and Bond 1979) and the MacKay River (Machniak et al. in prep.).

Evidence from tag returns suggests that the walleye found in the Mildred Lake study area are part of the Lake Athabasca population and return to the lake to overwinter. It is clear, however, that this is not the case for all fish as one walleye, tagged in spring 1977, was recaptured in spring 1978 in the Pembina River approximately 600 km upstream from the point of tagging.

Young-of-the-year walleye drift through the Mildred Lake area during late June and July as they move to rearing areas in the lower Athabasca River or Lake Athabasca.

5.2.3.7 Food habits. Analysis of stomach samples collected during 1976 indicates that walleye from the Athabasca River depend largely on fish for their diet although aquatic insects are important food items at certain times of the year. Fish remains occurred in more than 86% of young-of-the-year walleye stomachs that contained food. Among older walleye, fish accounted for 80% of the total food volume. Fish species identified from walleye stomach contents included suckers, flathead chub, mountain whitefish, trout-perch, burbot, goldeye, Arctic grayling, slimy sculpin, and yellow perch. The invertebrate component of the diet of adult walleye consisted largely of nymphal stages of the orders Plecoptera, Odonata, and Ephemeroptera which accounted for 14% of the total food volume.

5.2.4 Longnose Sucker

5.2.4.1 Distribution and relative abundance. Over the two years of the study, longnose suckers were fourth in abundance among fish captured by gill nets, large mesh seines, and angling. While accounting for only 12% of the total catch in these gear types, longnose suckers were extremely abundant in the Mildred Lake study area during April and May 1977 (Figure 5). This early season abundance is known to be associated with movements onto spawning grounds in tributary streams such as the Muskeg River (Bond and Machniak 1977, 1979), the Steepbank River (Machniak and Bond 1979), the MacKay River (Machniak et al. in prep.), and in the Athabasca River upstream of Fort McMurray (Tripp and McCart in prep.).

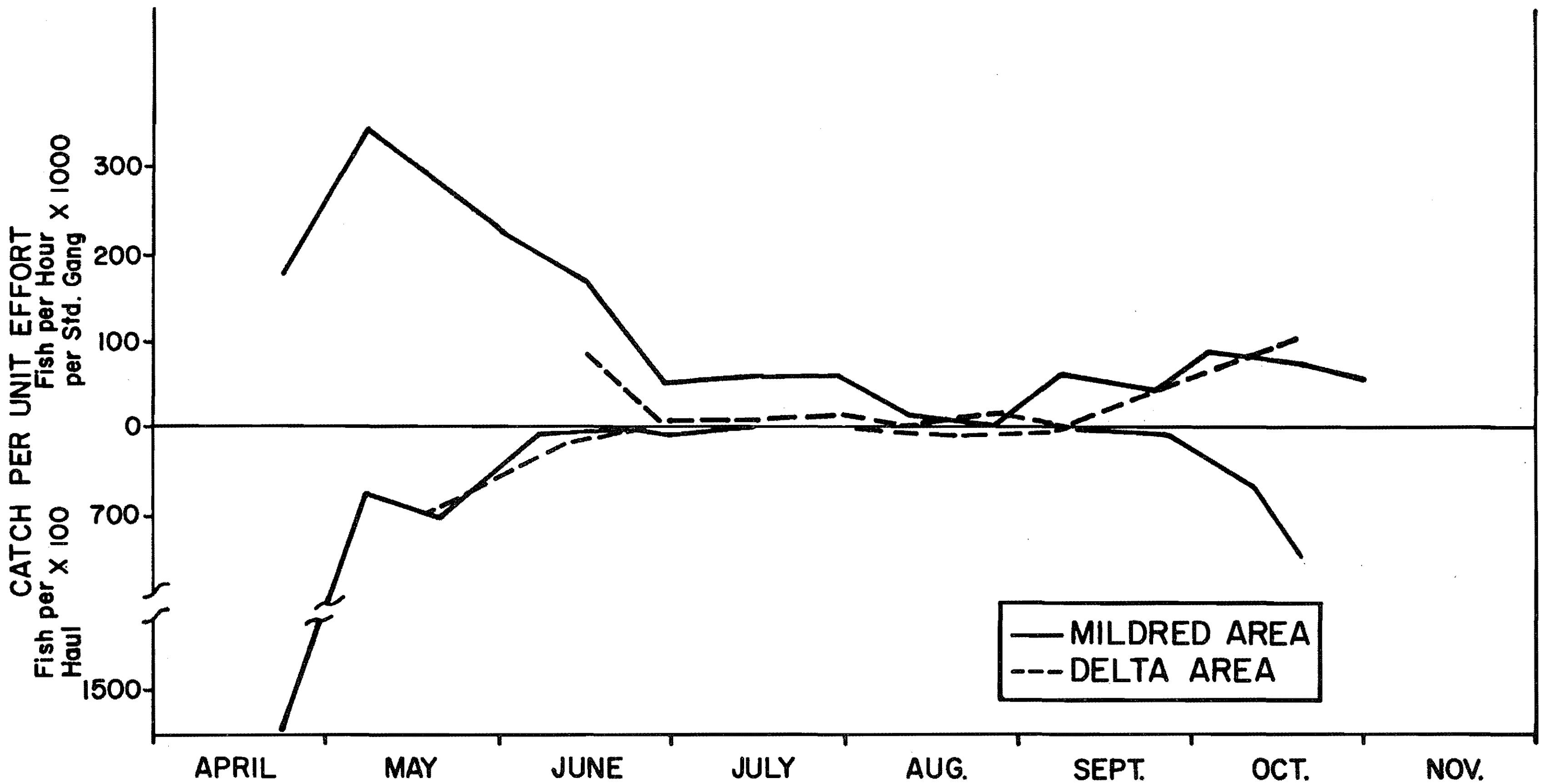

Figure 5. Seasonal changes in catch-per-unit-effort for longnose suckers captured in standard gangs and large mesh seines in the Mildred Lake and Delta study areas of the Athabasca River, 1977.

After leaving the spawning streams in late May and June, longnose suckers quickly left the Mildred Lake study area and were captured only in small numbers throughout the summer. In the Delta study area as well, catch-per-unit-effort remained low during the summer. An abundance peak recorded in late autumn (Figure 5) indicates that some suckers remained in the tributaries throughout the summer and returned to the Athabasca River as freeze-up approached. Machniak and Bond (1979) showed this to be the case in the Steepbank River.

5.2.4.2 Age and growth. Suckers captured during the study ranged in fork length from 12 to 549 mm. Young-of-the-year suckers, which often could not be identified to species, had fork lengths of from 12 to 88 mm. Excluding young-of-the-year, longnose suckers varied from 180 to 549 mm in fork length with the majority (92%) being between 340 and 479 mm.

Ages, determined from fin rays for 145 longnose suckers, ranged from 3 to 19 years; however, few fish exceeded 13 years of age and most (61%) belonged to age groups 6 to 11 inclusive.

5.2.4.3 Sex and maturity. Among longnose suckers for which sex was determined by gonadal inspection, the sex ratio did not vary significantly from unity ($P > 0.05$) either within age groups or in the overall sample. The youngest mature male sucker was five years old while the youngest mature female was age 6.

5.2.4.4 Spawning. Longnose suckers were abundant in tributary mouths within the Mildred Lake study area in late April and early May 1977. A reduction in catch-per-unit-effort occurred in early May, however, as longnose suckers moved onto spawning grounds in tributary streams such as the Muskeg River (Bond and Machniak 1977, 1979), the Steepbank River (Machniak and Bond 1979), the MacKay River (Machniak et al. in prep.), and in the Athabasca River upstream of the Mildred Lake study area (Tripp and McCart in prep.).

Although the act was not observed during the present study, longnose suckers are known to spawn between late April and mid-May in the project study area. In 1977, spent longnose suckers were not captured in the Athabasca River until 2 June. Young-of-the-year suckers were present throughout both the Mildred Lake and Delta study area by mid-June.

5.2.4.5 Fecundity. Fecundity estimates were obtained for 12 mature female longnose suckers captured in the Mildred Lake study area between 1 and 5 May 1977. These fish (387 to 491 mm F.L.) had estimated fecundities ranging from 19 408 to 44 402 with a mean of 29 203 eggs per female.

5.2.4.6 Migrations and movements. A large migration of mature longnose suckers entered the Mildred Lake study area during April and May. The presence of suckers in tributary mouths of this area by late April indicates that the upstream migration in the Athabasca River was initiated under ice-cover.

In 1977, longnose suckers began migrating into tributaries by 25 April. The spawning run in the Steepbank River peaked between 2 and 4 May (Machniak and Bond 1979) while that in the Muskeg River peaked on 4 and 5 May (Bond and Machniak 1979). The 1976 Muskeg River run began on 28 April and peaked on 9 and 10 May (Bond and Machniak 1977). A longnose sucker run is also known to occur in the MacKay River (Machniak et al. in prep.).

After spawning, most longnose suckers left the spawning streams and returned downstream, although some fish remained in the tributaries throughout the summer, leaving just prior to freeze-up (Bond and Machniak 1977; Machniak and Bond 1979). Tag return evidence indicates a return to Lake Athabasca for overwintering.

Large numbers of young-of-the-year suckers of two species appeared in the Mildred Lake study area in mid-June 1977. By late August these fry had passed the Delta study area (Figure 6) en route to nursery areas in the lower delta or Lake Athabasca.

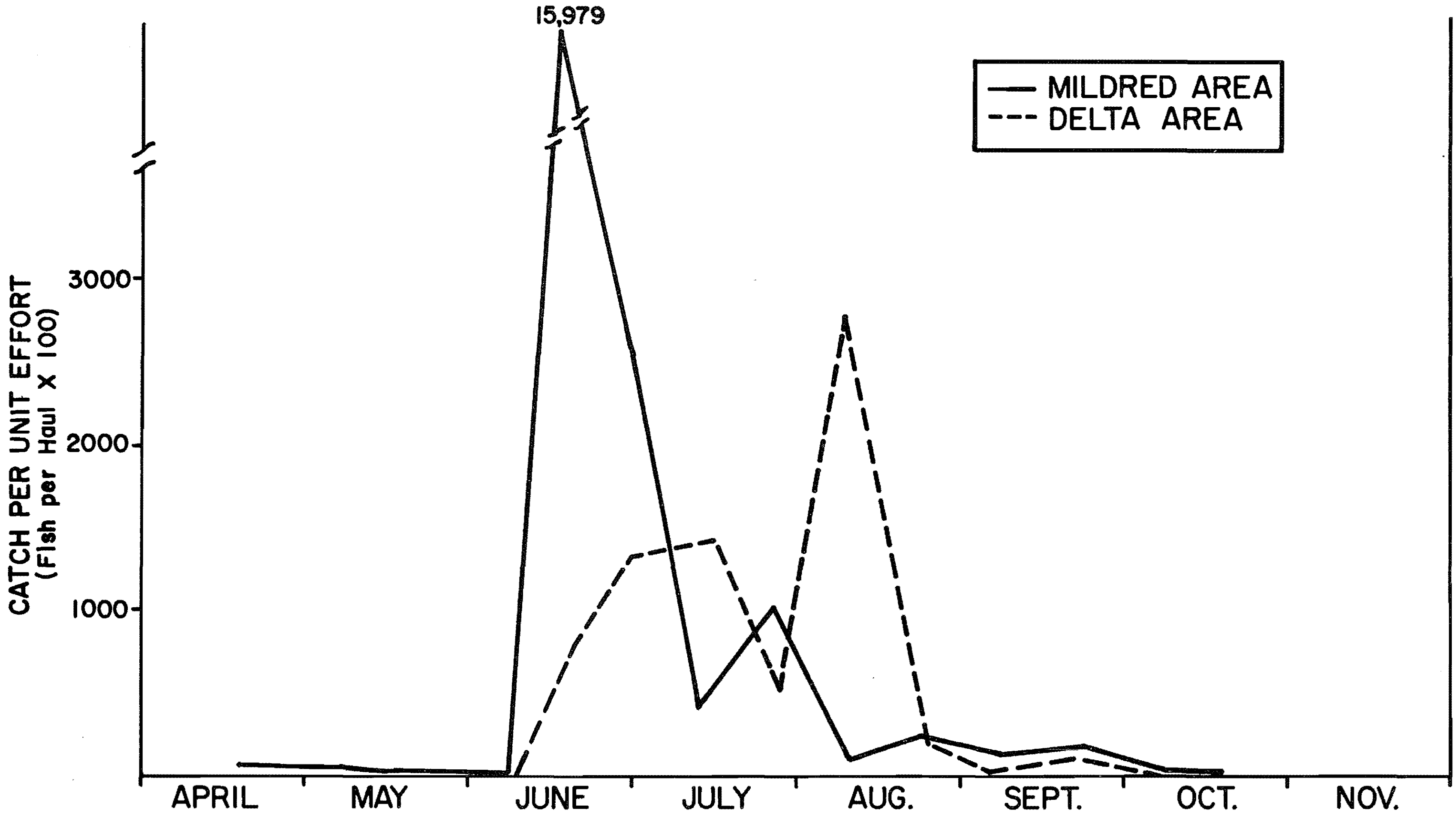

Figure 6. Seasonal changes in catch-per-unit-effort for young-of-the-year suckers captured in small mesh beach seines in the Mildred Lake and Delta study areas of the Athabasca River, 1977.

5.2.4.7 Food habits. Stomach analyses were done for 25 adult longnose suckers captured in the Mildred Lake study area during 1976. Twenty-four percent of these fish had empty stomachs. Hemiptera (Corixids) were the most common food item, occurring in 37% of those stomachs containing food. Unidentifiable insects occurred in 42% of all stomachs that contained food, while detritus (32%), Pelecypoda (16%), and Ephemeroptera nymphs (11%) accounted for the remainder of the stomach contents.

5.2.5 Northern Pike

5.2.5.1 Distribution and relative abundance. Northern pike occurred throughout both the Mildred Lake and Delta study areas but were not captured in large numbers either in standard gangs or large mesh beach seines. Catch-per-unit-effort values were high in the Mildred Lake study area in late April and early May (Figure 7) at which time pike were abundant around tributary mouths. Throughout the summer, catch-per-unit-effort remained low but tended to increase during September and October. The Delta study area produced higher catch-per-unit-effort values for pike during the summer than did the Mildred Lake study area but pike became less abundant in this area during the autumn.

5.2.5.2 Age and growth. Northern pike from the Athabasca River ranged in fork length from 19 to 1099 mm with young-of-the-year varying from 19 to 185 mm. The majority (74%) of the remainder were between 320 and 619 mm long.

Scale ages for 293 northern pike ranged from 0+ to 7 years but age groups 3, 4, and 5 comprised the majority of those older than age 0+, both in 1976 (68%) and 1977 (77%).

Young-of-the-year pike, collected at the mouth of Leggett Creek on 16 to 18 June 1977, had a mean fork length of 28 mm (range 19 to 36 mm) while six fish captured 28 June at the mouth of the Tar River had a mean fork length of 41 mm (range 39 to 44 mm). In the

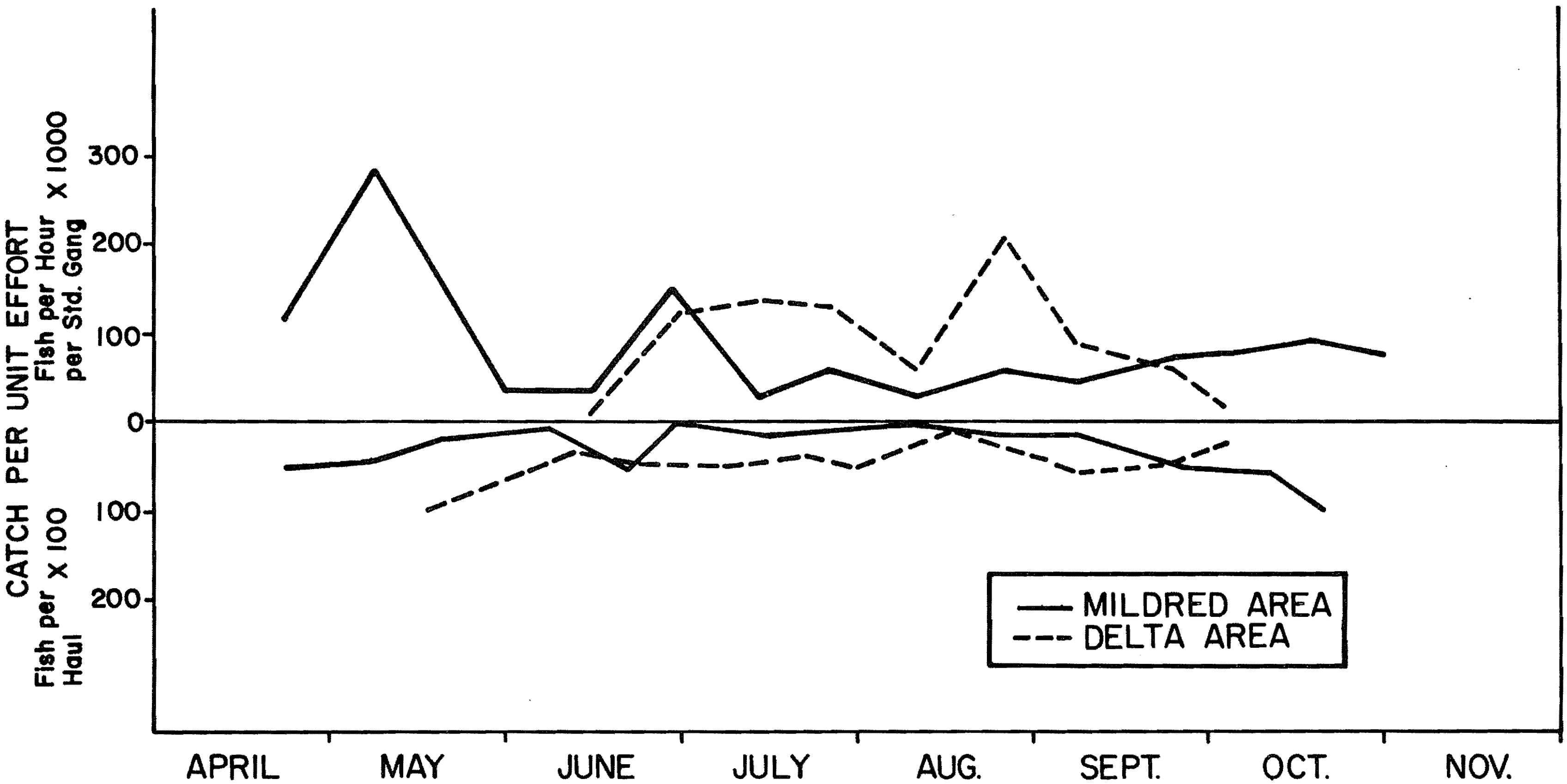

Figure 7. Seasonal changes in catch-per-unit-effort for northern pike captured in standard gangs and large mesh seines in the Mildred Lake and Delta study areas of the Athabasca River, 1977.

Delta study area, nine young-of-the-year pike, taken between 14 and 28 July, ranged in fork length from 93 to 119 mm with a mean of 106 mm. The maximum size observed for young-of-the-year pike was 185 mm and 42 g.

Female pike tended to grow more rapidly than males and were generally longer and heavier than males of equal age.

5.2.5.3 Sex and maturity. Within age groups and in the overall sample, the male to female ratio for northern pike did not differ significantly from unity ($P > 0.05$).

Although some pike in the study area may spawn as early as age 2, most do not reach sexual maturity until age 3 or 4. As reported in other studies, both within the AOSERP area (Machniak and Bond 1979; Machniak et al. in prep.) and elsewhere (Scott and Crossman 1973), male pike tend to achieve sexual maturity at an earlier age than females.

5.2.5.4 Spawning. Northern pike generally spawn in April and early May, immediately after the ice melts, at water temperatures of 4.4° to 11.1°C (Scott and Crossman 1973). While pike spawn in a variety of habitats, the presence of vegetation appears to be a requirement of the spawning site (Machniak 1975). Spawning of northern pike was not observed in either the Mildred Lake or Delta study area although both areas contain suitable spawning habitat in restricted areas such as side sloughs. Some spawning may also occur in tributaries although the Muskeg River (Bond and Machniak 1977, 1979) and the Steepbank River (Machniak and Bond 1979) do not appear to be of major importance in this regard.

During the 1977 study, ripe northern pike were captured in the Mildred Lake study area between 27 April and 9 May and the first spent fish were taken on 7 May. Young-of-the-year pike first appeared in mid-June (19 to 36 mm) but were never found in abundance in either study area.

5.2.5.5 Fecundity. The estimated fecundity for five mature female northern pike (554 to 657 mm F.L.), captured in the Mildred Lake study area between 1 and 8 May 1977, varied from 17 764 to 42 962 with a mean of 28 896 ova per female.

5.2.5.6 Migrations and movements. High catch-per-unit-effort values recorded in the Mildred Lake study area in late April and early May 1977 indicated pike concentrations near tributary mouths at that time. During May, catch-per-unit-effort values decreased (Figure 7) suggesting a movement of pike out of the Athabasca River into the tributaries. Counting fence operations on the Muskeg River (Bond and Machniak 1979) and the Steepbank River (Machniak and Bond 1979) confirmed the occurrence of such migrations. The runs in both these tributaries included only a small proportion of ripe fish, suggesting that neither stream provides major spawning grounds for pike. Although some spawning probably occurs in these tributaries, their main function appears to be the provision of summer feeding areas.

During the summer, the pike in the Mildred Lake study area remain in the lower reaches of tributary streams or return to the Athabasca River where they tend to frequent tributary mouths. Rising catch-per-unit-effort values during September and October probably reflect a movement of pike out of the tributaries to overwintering areas in the Athabasca River.

In the Delta study area, a decrease in the catch-per-unit-effort in the autumn indicates that pike may leave that area at that time to overwinter either upstream in the Athabasca River or downstream in Lake Athabasca.

Tagging results indicate that pike in both study areas tend to move around very little during the summer although individual fish may move considerable distances.

5.2.5.7 Food habits. One hundred and twenty-five pike stomachs were analyzed in 1976, of which 78 (62%) contained no food. Pike which did contain food had fed predominantly on fish which comprised

95% of the total food volume. Flathead chub and suckers each occurred in 15% of all stomachs that contained food, accounting for 23% and 16% of the total food volume, respectively. Other fish species consumed by pike included trout-perch, northern pike, walleye, mountain whitefish, brook stickleback, lake whitefish, emerald shiner, and goldeye. Also found occasionally in the stomach contents were Plecoptera and Odonata nymphs, frogs, and mice.

5.2.6 White Sucker

5.2.6.1 Distribution and relative abundance. White suckers made up 5% of the total catch in large mesh seines and gill nets. Over two years, this species was sixth in abundance among fish taken in these gear types.

White suckers were extremely abundant in the Mildred Lake study area during April and May 1977 (Figure 8). This early season abundance is known to be associated with movements onto spawning grounds in tributary streams such as the Muskeg River (Bond and Machniak 1977, 1979), the Steepbank River (Machniak and Bond 1979), and the MacKay River (Machniak et al. in prep.). After leaving the spawning streams in late May and early June, white suckers quickly left the Mildred Lake study area. Throughout the summer, they were taken only in small numbers in both study areas. Machniak and Bond (1979) have shown that some immature migrant white suckers remain in the spawning streams throughout the summer, leaving just prior to freeze-up.

5.2.6.2 Age and growth. White suckers ranged in fork length from 12 to 589 mm. Fork lengths for young-of-the-year varied from 12 to 77 mm while, of the remainder, 81% were between 340 and 519 mm in length.

Fin ray ages for 16 white suckers ranged from 4 to 11 years. The maximum age reported for white suckers in the AOSERP area is 17 years (Bond and Machniak 1977).

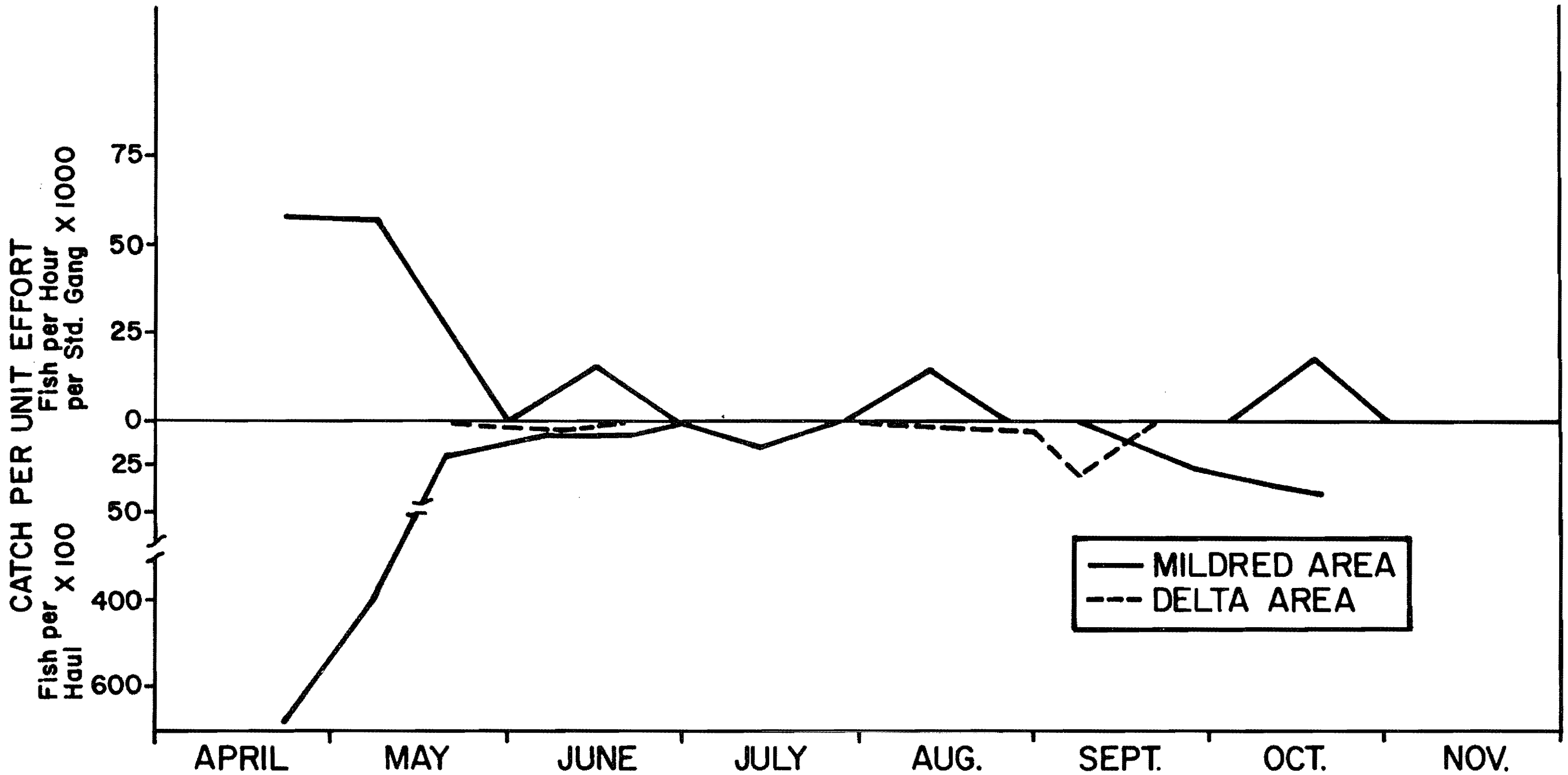

Figure 8. Seasonal changes in catch-per-unit-effort for white suckers captured in standard gangs and large mesh seines in the Mildred Lake and Delta study areas of the Athabasca River, 1977.

5.2.6.3 Sex and maturity. Based on a limited number of samples, the present study indicates that both male and female white suckers mature at five years of age. Other studies have indicated that white suckers in the AOSERP area may mature as early as age 3, and that males tend to achieve sexual maturity a year earlier than females (Bond and Machniak 1977, 1979; Machniak and Bond 1979).

5.2.6.4 Spawning. It is not known whether areas of the Athabasca River are utilized for spawning purposes by white suckers. However, several tributaries in the Mildred Lake study area are known to be used as spawning streams. These include the Muskeg River (Bond and Machniak 1977, 1979), the Steepbank River (Machniak and Bond 1979), and the MacKay River (Machniak et al. in prep.). These authors indicate that white suckers spawn in the tributaries between late April and mid-May.

5.2.6.5 Fecundity. Fecundity estimates for 11 white suckers (370 to 565 mm F.L.), captured in the Mildred Lake study area between 1 and 4 May 1977, ranged from 31 566 to 85 461 with a mean of 54 766 ova per female.

5.2.6.6 Migrations and movements. A large white sucker migration entered the Mildred Lake study area during April and May. As with longnose suckers, the presence of white suckers in tributary mouths of the Mildred Lake study area in late April indicates that the upstream migration in the Athabasca River was initiated under ice-cover.

In 1977, white suckers began migrating into tributaries by 25 April. The spawning run in the Steepbank River peaked between 2 and 5 May (Machniak and Bond 1979) while the run in the Muskeg River peaked on 7 and 8 May (Bond and Machniak 1979). The 1976 Muskeg River run began on 29 April and peaked on 7 to 10 May (Bond and Machniak 1977). A white sucker migration is also known to occur in the MacKay River (Machniak et al. in prep.).

After spawning, most white suckers left the spawning streams and returned downstream although some fish remained in the tributaries throughout the summer, leaving just prior to freeze-up (Bond and Machniak 1977; Machniak and Bond 1979). Tag return evidence indicates a return to Lake Athabasca for overwintering.

Large numbers of young-of-the-year suckers of two species appeared in the Mildred Lake study area in mid-June 1977 but they had largely drifted out of this study area by mid-July. By late August, this fry migration had passed the Delta study area (Figure 6) en route to nursery areas in the lower delta or Lake Athabasca.

5.2.6.7 Food habits. Of eight adult white sucker stomachs examined, four contained pelecypods, five contained unidentifiable insect parts, and two contained corixids and detritus.

5.2.7 Flathead Chub

5.2.7.1 Distribution and relative abundance. Flathead chub were seventh in abundance among species captured by gill nets, large mesh seines, and angling. Over two years, chub made up 4% of the total catch produced by these gear types.

Flathead chub are found throughout both the Mildred Lake and Delta study areas and at least as far upstream in the Athabasca River as Brule Rapids, 93 km above Fort McMurray (Jones et al. 1978). They appear to be almost totally confined to the turbid waters of the Athabasca River. Studies on the Muskeg River (Bond and Machniak 1977, 1979), the Steepbank River (Machniak and Bond 1979), the Clearwater River (Jones et al. 1978), and the MacKay RIver (Machniak et al. in prep.) indicate that few chub enter tributaries.

Catch-per-unit-effort for larger chub was low in the Delta study area throughout the summer in 1977. In the Mildred Lake study area, catch-per-unit-effort was high in May and June and generally decreased throughout the summer, although large mesh seines produced an abundance peak in early September (Figure 9). These results

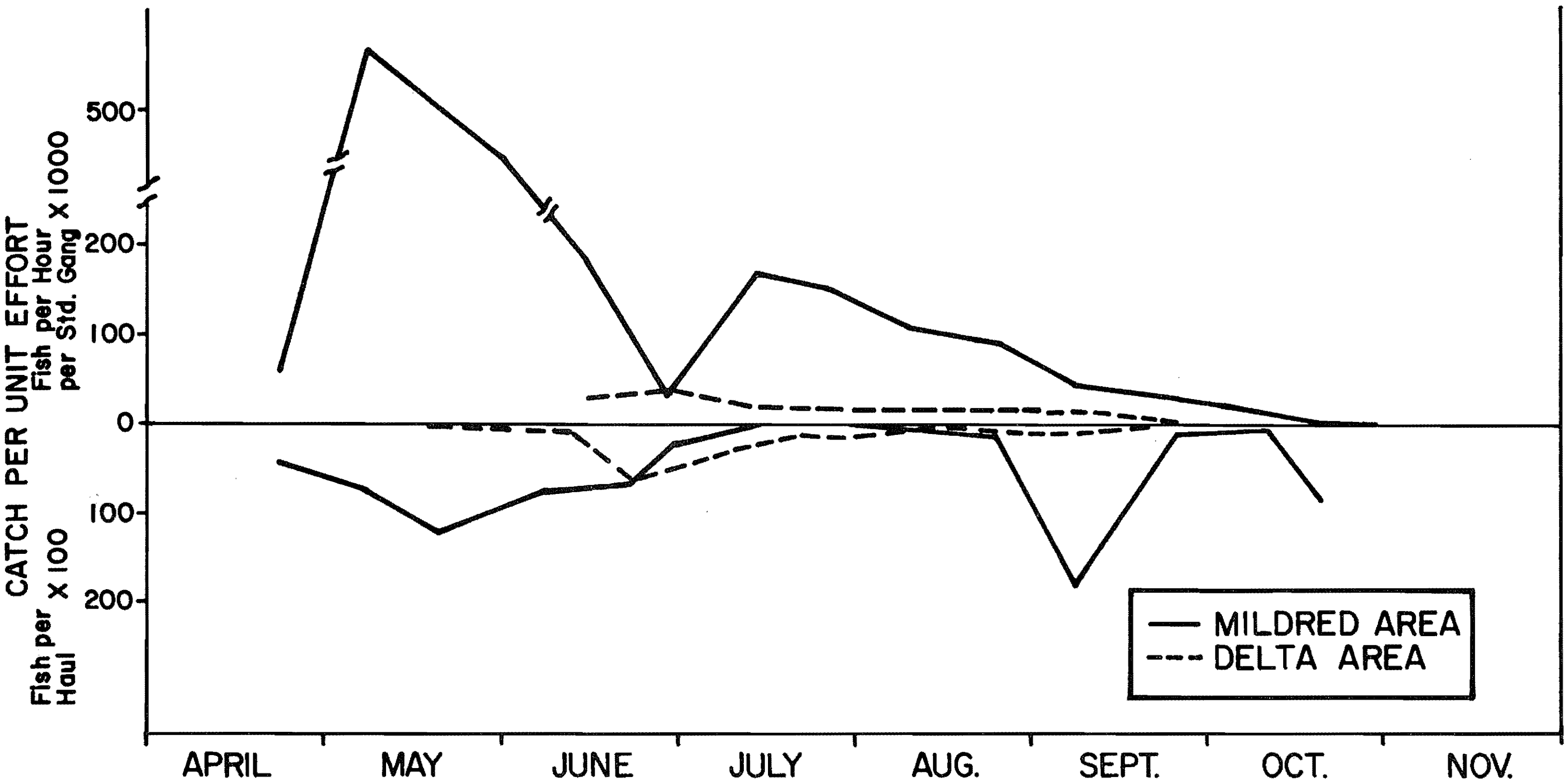

Figure 9. Seasonal changes in catch-per-unit-effort for flathead chub captured in standard gangs and large mesh seines in the Mildred Lake and Delta study areas of the Athabasca River, 1977.

suggest that large flathead chub (> 150 mm) are more abundant in the Mildred Lake study area than in the Delta study area but that the population is somewhat mobile.

Young-of-the-year chub were not taken in large numbers in the Mildred Lake study area until 18 October 1977. On that date, this year class accounted for 52% of the total catch in small mesh seine hauls although occurring in only three of 21 hauls. In the Delta study area, on the other hand, small chub were abundant throughout the summer. The greatest catch-per-unit-effort in small mesh seines occurred in mid-July with the appearance of young-of-the-year.

5.2.7.2 Age and growth. Flathead chub ranged in fork length from 12 to 322 mm but the length frequency distribution varied considerably between the two study areas. In the Mildred Lake study area, 26% of the total catch of flathead chub over two years consisted of fish less than 90 mm in fork length while 70% exceeded 150 mm. The smaller group includes young-of-the-year and one-year-old fish. Few one-year-olds were captured during 1977 in the Mildred Lake study area. The Delta sample consisted predominantly (88%) of fish less than 90 mm in fork length while only 8% of the total catch exceeded 150 mm. The paucity of flathead chub in the 90 to 140 mm range probably reflects the selectivity of the sampling gear.

Scale ages for flathead chub varied from 0+ to 8 years but males did not exceed age 6. Females, in addition to living longer than males, tended to exceed them, both in fork length and weight, at a given age.

5.2.7.3 Sex and maturity. Female flathead chub outnumbered males in the samples from the Mildred Lake study area, the sex ratio differing significantly from unity in both years of the study ($P < 0.05$).

The earliest at which sexually mature fish were observed was age 3 for both sexes. However, most fish probably do not spawn until age 4.

While mature fish were common in the Mildred Lake study area, only seven mature fish (all females) were captured in the Delta study area. The population in the Delta study area seems to consist largely of juvenile fish, suggesting that this area may be an important rearing area.

5.2.7.4 Spawning. As chub are seldom captured in clear water (McPhail and Lindsey 1970), it is probable that spawning occurs within the Athabasca River itself rather than in tributaries. Furthermore, the greater abundance of mature fish taken in the Mildred Lake than in the Delta study area suggests that flathead chub spawning, although not observed, occurs in or upstream of the Mildred Lake study area.

Ripe and spent individuals were captured from early June to mid-August, indicating an extended spawning season. Eight percent of flathead chub examined during the first half of June 1977 were spawned out. Young-of-the-year, ranging from 14 to 39 mm in fork length, appeared in July. Few ripe or spent fish were captured in the Delta study area suggesting that little spawning occurs in that area.

5.2.7.5 Fecundity. Fecundity estimates were obtained for 11 mature female flathead chub (235 to 297 mm F.L.) captured in the Mildred Lake study area on 2 June 1977. Estimates ranged from 7 000 to 15 170 with a mean of 10 564 ova per female.

5.2.7.6 Migrations and movements. The concentration of flathead chub observed in the Mildred Lake study area in May and June 1977 may have indicated that a spawning migration was underway at that time. After spawning, chub apparently remained in the river during the summer although a post-spawning dispersal resulted in lower catch-per-unit-effort values.

Tags were applied to only 78 flathead chub during the study, of which two were recaptured. Both recaptures were made at the original tagging sites. One fish had been at large for 28 days, the other for 245 days.

5.2.7.7 Food habits. The diet of flathead chub was extremely varied but consisted primarily of mature and immature stages of terrestrial and aquatic insects. Nine orders of insects were identified from the stomach contents. Diptera larvae were the food item most frequently encountered, occurring in 24% of all stomachs examined. Other insect orders important in the diet of this species were Ephemeroptera (17% of all stomachs), Hemiptera (14%), Hymenoptera (13%), Coleoptera (11%), and Trichoptera (10%). Arachnida, Nematoda, Gastropoda, Pelecypoda, Cladocera, Ostracoda, shrew and fish remains, and plant material were also found in the stomachs.

5.2.8 Emerald Shiner

5.2.8.1 Distribution and relative abundance. The emerald shiner is found throughout the lower Athabasca River, sometimes occurring in enormous numbers. Over two years, emerald shiners occurred in 38% of small mesh seine hauls made in the upstream study area, accounting for 7% of all fish taken in that gear. In the Mildred Lake study area, shiners were taken only in small numbers during April and May but were common during June and July, especially in 1976 (Figure 10). Catch-per-unit-effort declined throughout the summer but, in 1977, rose sharply during September as a result of the appearance of large numbers of young-of-the-year.

Emerald shiners occurred in much higher numbers in the Delta study area than in the Mildred Lake study area. In the Delta study area, this species was captured in 61% of all seine hauls and comprised 75% of the catch in small mesh seines. Catch-per-unit-effort fluctuated drastically throughout the summer (Figure 10) with a peak occurring 6 September, on which date an estimated 10 000 shiners were taken in a single seine haul.

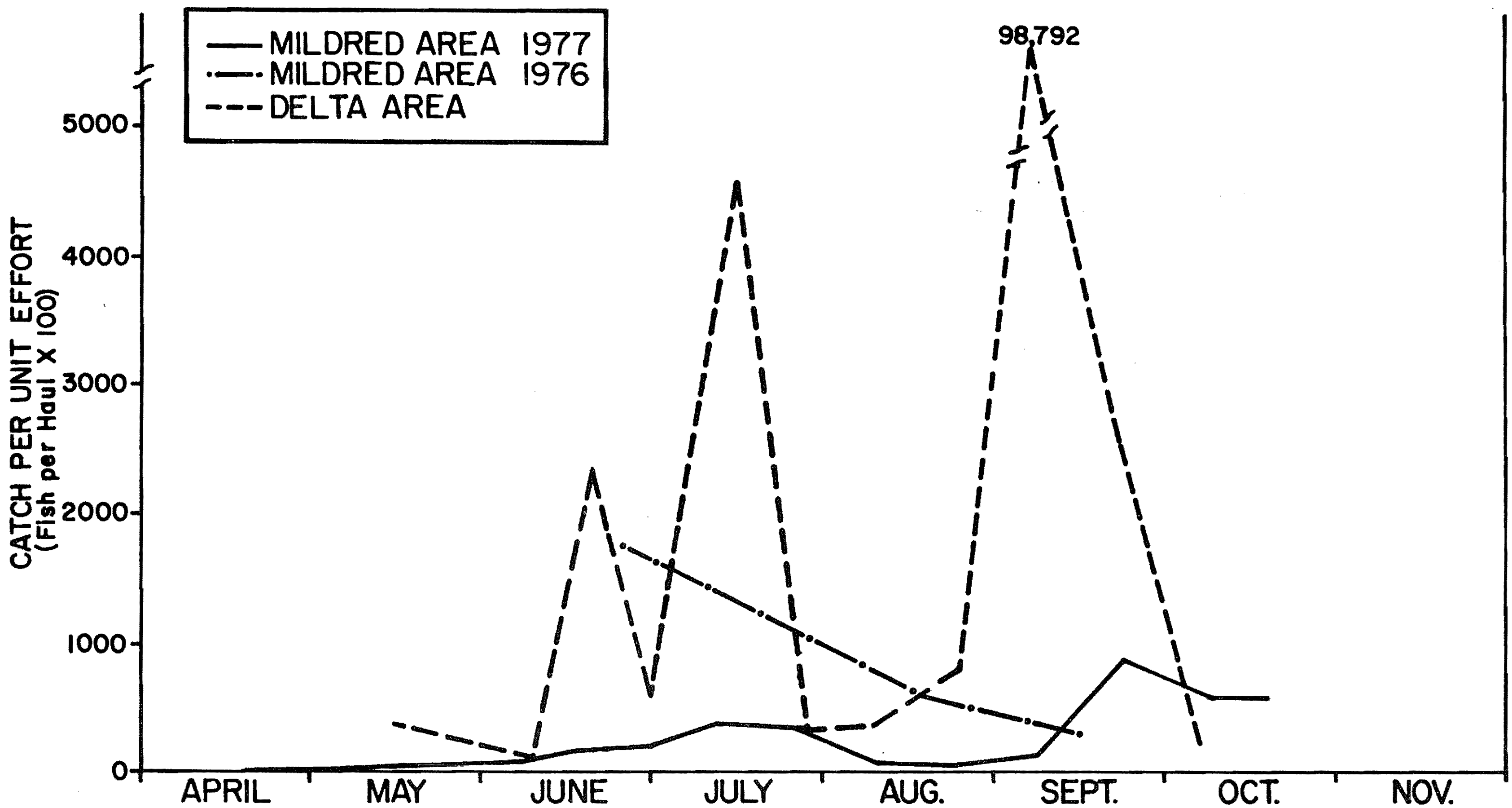

Figure 10. Seasonal changes in catch-per-unit-effort for emerald shiners captured in small mesh beach seines in the Mildred Lake and Delta study areas of the Athabasca River, 1976 and 1977.

5.2.8.2 Age and growth. Emerald shiners in the Athabasca River ranged in otolith age from 0+ to 3 years. However, only two age 3 fish were taken, indicating that few shiners live beyond age 2 in this area.

Male and female shiners increased in fork length at the same rate but females tended to be heavier than males at age 2. This difference was statistically significant ($P < 0.05$) in the Delta sample.

Emerald shiners captured during the study varied from 13 to 100 mm in fork length. Age groups were easily identified by their length frequencies, the approximate ranges for each age group being as follows: 0+ (13 to 29 mm); 1 (28 to 73 mm); 2 (62 to 91 mm).

The age structure of emerald shiner samples varied with location and time of year. Shiners of age group 0+ were not captured until September. In September and October 1977, this age group was very abundant in the Mildred Lake study area, accounting for 91% of the total catch in those months. Only two young-of-the-year had been captured in the Delta study area as of 7 October.

Few age 1 shiners were captured in the Mildred Lake study area. However, huge numbers of this age group were taken in the Delta study area throughout the summer.

Two-year-old emerald shiners were common in the Delta study area in May and June but were taken only in small numbers thereafter. On the other hand, age 2 fish, which occurred only in small numbers in the Mildred Lake study area during May, were very common there in June and July. After July, their abundance in the Mildred Lake study area decreased considerably.

This information suggests a pattern of movements and timing of events that are discussed in later sections.

5.2.8.3 Sex and maturity. Male and female emerald shiners occurred in a 1:1 ratio. Both male and female shiners reached sexual maturity for the first time at age 2. Among two-year-old fish, 73% of the males and 48% of the females examined were mature. The smallest mature fish were in the 56 to 69 mm fork length range for both sexes.

Age 2 fish, which were abundant early in the year, became scarce near the end of July. More than 82% of all age 2 shiners were captured prior to that date and virtually all of these fish, of both sexes, were mature. After the end of July, the age 2 population consisted of a few spent females and fish (mostly females) that would not spawn in 1977. No spent males were recorded. This suggests a severe post-spawning mortality among age 2 fish. A small proportion of this age class survives, however, to spawn as three-year-olds.

5.2.8.4 Spawning. Spawning of emerald shiners was not observed during the study. However, it is believed to have occurred in the Athabasca River during June and July 1977. Both male and female shiners were observed to be close to spawning condition between 8 June and 13 July in the Mildred Lake study area and spent females were captured there between 25 July and 11 August.

The greater abundance of age 2 fish and the earlier appearance of young-of-the-year in the Mildred Lake study area than in the Delta study area, suggests that the Mildred Lake study area, or areas upstream of it, are more important as spawning habitat for this species than are the lower reaches. The possibility that some spawning occurs below the Mildred Lake study area, or in the Delta study area, cannot however, be ruled out.

5.2.8.5 Fecundity. Total egg counts were made for 15 fully mature emerald shiner females captured between 8 and 19 June 1977 in the Mildred Lake study area. For these fish (73 to 100 mm F.L.), egg numbers varied from 1 124 to 2 263 with a mean of 1 465 ova per female.

5.2.8.6 Migrations and movements. Because no marking of emerald shiners was conducted, there is no information on movements of individual fish. However, on the basis of fluctuations in catch-per-unit-effort, maturity, and age composition, it is possible to draw certain inferences with respect to movements of this species in the lower Athabasca River.

The major spawning areas for emerald shiners are assumed to be within or upstream of the Mildred Lake study area. Spawning occurs in late June and July, the spawning population consisting of two-year-old fish plus a few age 3 individuals. A severe post-spawning mortality occurs among age 2 fish. After emergence, young-of-the-year move downstream, eventually to the delta where they spend their next year of life. The Delta study area appears to be critical as a rearing area for emerald shiners. After spending two winters in the delta (or Lake Athabasca), emerald shiners migrate out of the delta onto the spawning grounds as two-year-old fish. Both spawners and non-spawners participate in this migration.

5.2.8.7 Food habits. The food of emerald shiners, based on examination of the contents of 139 stomachs, consisted primarily of immature insects belonging to the orders Diptera, Plecoptera, Ephemeroptera, Hymenoptera, Hemiptera, and Trichoptera. Diptera larvae were the most frequently encountered food item, occurring in 35% of all stomachs that contained food. Other food items included Cladocera, Arachnida, and Gastropoda.

5.2.9 Trout-perch

5.2.9.1 Distribution and relative abundance. Trout-perch is perhaps the most abundant and widely distributed forage fish species occurring in the AOSERP area. Found in high numbers in both the Mildred Lake and Delta study areas, this species was taken in 69% of all small mesh seine hauls made over two years and accounted for 25% of the total catch in that gear. The greatest catches of trout-perch were made over sandy substrate along islands and mid-channel sand bars.

Trout-perch displayed similar trends in abundance throughout the summer in both study areas (Figure 11). In general, the

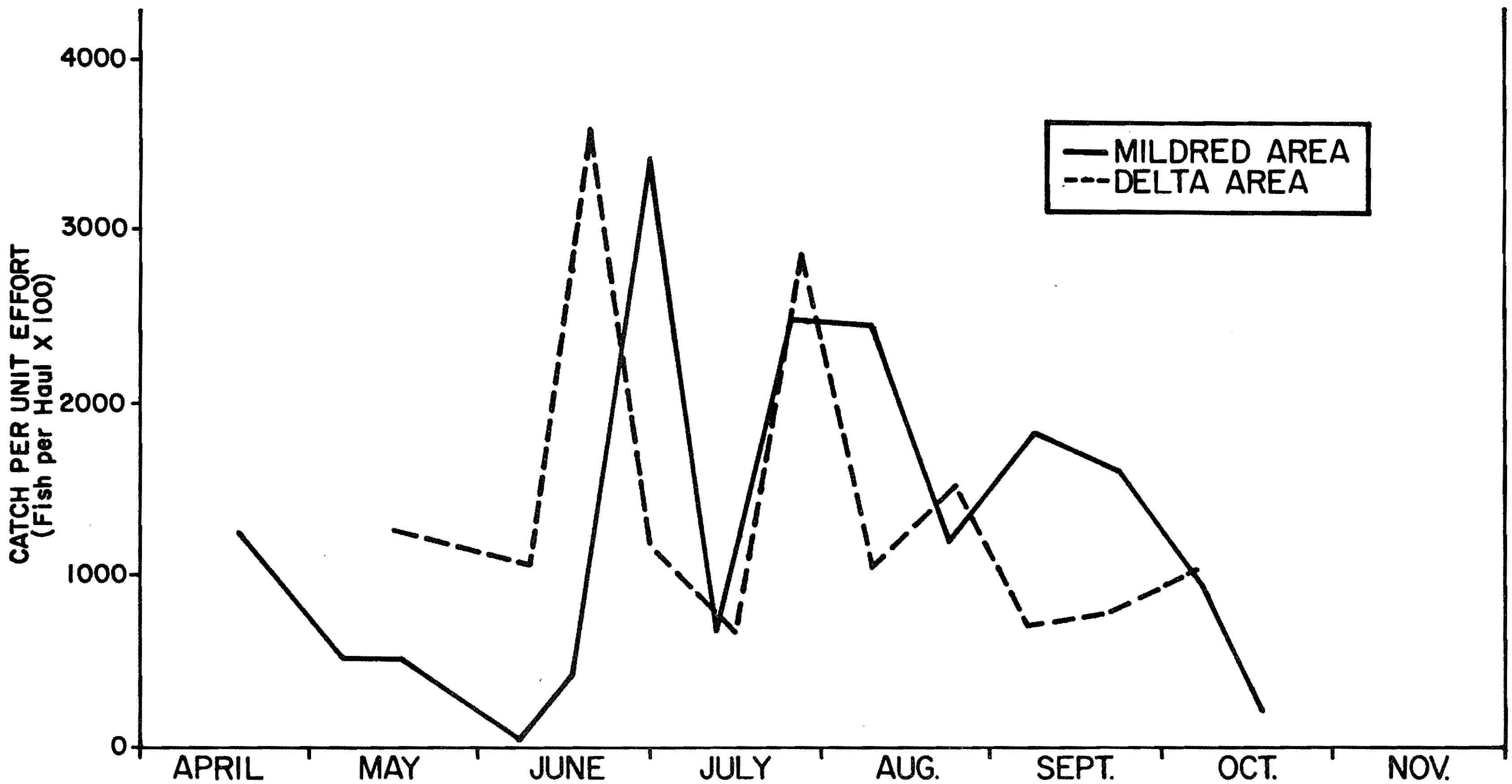

Figure 11. Seasonal changes in catch-per-unit-effort for trout-perch captured in small mesh beach seines in the Mildred Lake and Delta study areas of the Athabasca River, 1977.

catch-per-unit-effort was low in April and May but peaked in mid- to late June as a result of the appearance of young-of-the-year. Catch-per-unit-effort tended to decrease over the remainder of summer as young-of-the-year dispersed. A severe crash in catch-per-unit-effort, occurring in mid-July, coincided with high flood waters in the Athabasca River.

5.2.9.2 Age and growth. Trout-perch captured during this study ranged in fork length from 10 to 89 mm with the majority (62%) being between 25 and 49 mm. Young-of-the-year had fork lengths of from 10 to 22 mm in early June and from 19 to 58 mm in October.

Otolith ages varied from 0+ to 3 years. However, of the total, young-of-the-year and one-year-olds accounted for 63% and 33% respectively.

5.2.9.3 Sex and maturity. Female trout-perch outnumbered males in all age groups. Differences from a sex ratio of unity were statistically significant ($P < 0.05$) at age 0+ in the Delta study area, at age 1 in both areas, and in the overall sample.

Trout-perch in the study area begin to spawn at age 1, at which age 17% of males and 4% of females were mature. Among two-year-old fish, 86% of males and 65% of females were sexually mature.

5.2.9.4 Spawning. Spawning was not observed for trout-perch during the present study but ripe males and females were collected in the Mildred Lake study area during late April and early May 1977. Decreasing catch-per-unit-effort values during May (Figure 11) are believed to indicate a movement of trout-perch onto spawning grounds in tributary streams.

In 1977, spawning is believed to have commenced in late May or early June. Young-of-the-year trout-perch (10 to 22 mm in length) first appeared in the Athabasca River in early June in both the Mildred Lake and Delta study areas.

Age 1 and older fish, which dominated the trout-perch population during May and June, became less and less abundant as the summer progressed, suggesting a severe post-spawning mortality.

5.2.9.5 Fecundity. Total egg counts were performed on 12 mature female trout-perch (58 to 89 mm F.L.) captured in the Mildred Lake study area between 3 and 7 May 1977. Fecundity ranged from 192 to 421 with a mean of 275 eggs per female.

5.2.9.6 Migrations and movements. No marking of trout-perch was conducted during this study so no information exists concerning movements of individual fish. Nevertheless, the disappearance of trout-perch from the Athabasca River, in both the Mildred Lake and Delta study areas, during late April and May 1977, strongly suggests a movement into tributary streams. The capture of ripe trout-perch in the Steepbank River during May 1977 (Machniak and Bond 1979) and in the MacKay River in May 1978 (Machniak et al. in prep.) supports this suggestion.

The downstream migration of fry out of the tributaries and back to the Athabasca River occurred in the latter part of June 1977.

5.2.9.7 Food habits. The contents of 180 trout-perch stomachs were analyzed during the study, of which 17% were empty. Diptera larvae were the most common food item utilized by trout-perch, occurring in 75% of all stomachs that contained some food. Other food items identified included Trichoptera larvae, Ephemeroptera and Plecoptera nymphs, Amphipoda, Cladocera, Copepoda, Ostracoda, and Nematoda.

5.2.10 Lake Chub

5.2.10.1 Distribution and relative abundance. Lake chub were found throughout the Mildred Lake study area where they were captured most often near tributary mouths. This species was fourth in abundance among those captured in small mesh seines in this study area, accounting for 7% of the total catch in this gear over two years. Only five lake chub were taken in the Delta study area.

During 1977, lake chub abundance was highest in late July (Figure 12) when young-of-the-year formed the bulk of the catch. However, catch-per-unit-effort decreased to a low level during late summer and fall. During 1976, the catch-per-unit-effort rose throughout the summer to a peak in mid-September, after which time no collections were made.

Lake chub are known to be common in tributaries of the AOSERP study area (Griffiths 1973; Bond and Machniak 1977, 1979; Machniak and Bond 1979; Machniak et al. in prep.).

5.3.10.2 Age and growth. Otolith ages for lake chub varied from 0+ to 3 years but few fish were older than age 1. Studies on the Muskeg River (Bond and Machniak 1977, 1979) and Steepbank River (Machniak and Bond 1979) also failed to capture many chub older than age 1 although reporting a maximum age of 5 years.

Age 1 fish dominated the catch from the Mildred Lake study area in 1977, comprising 51% of all chub taken. This age group accounted for most chub captured in April, May, and June. Young-of-the-year, which accounted for 46% of all chub taken, dominated the catch from July on. During the 1976 study, young-of-the-year comprised 88% of the total catch of lake chub.

Lake chub captured during the study ranged in fork length from 17 to 94 mm, with 70% being between 25 and 39 mm.

5.2.10.3 Sex and maturity. Few mature lake chub were captured during the study. Males and females both appear to reach sexual maturity at age 3 and no fish less than age 3 were found to be mature. While females outnumbered males in the samples, the sex ratio was not significantly different from unity ($P > 0.05$).

5.2.10.4 Spawning. Lake chub spawning was not observed during the study. Although spawning locations are unknown, it is possible that

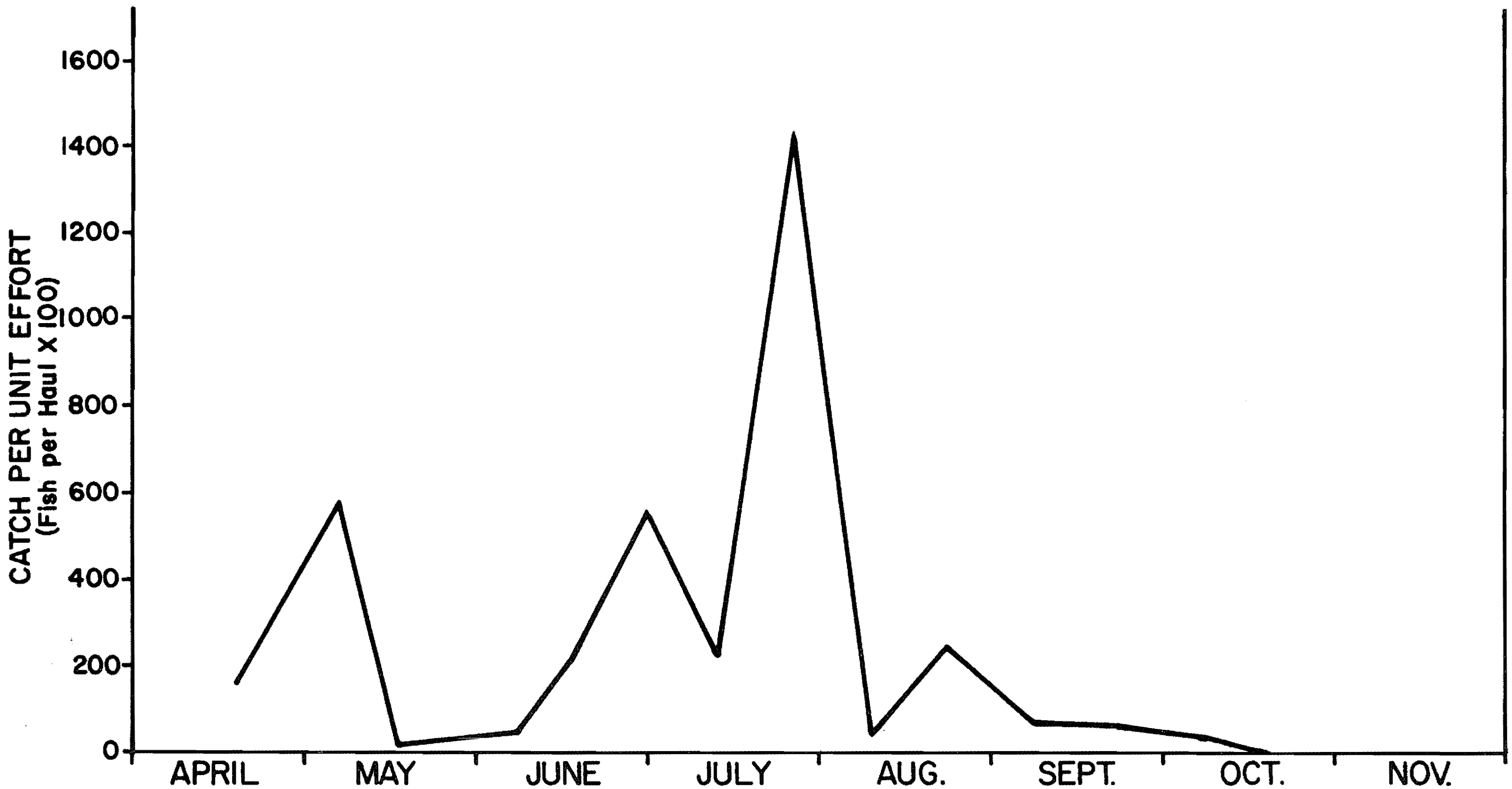

Figure 12. Seasonal changes in catch-per-unit-effort for lake chub captured in small mesh beach seines in the Mildred Lake study area of the Athabasca River, 1977.

spawning occurs in the lower reaches of tributary streams of the Mildred Lake study area during May or June. Spawning may also occur along the edges of the Athabasca River proper. Large numbers of young-of-the-year lake chub were taken in the Athabasca River during July 1977, as well as in August and September 1976.

Failure to capture many mature chub during the summer may indicate a severe post-spawning mortality for this species.

5.2.10.5 Migrations and movements. Because no marking of lake chub was carried out, there is no information as to movements of individual fish.

Although mature lake chub are often reported to migrate into spawning streams in early spring (Scott and Crossman 1973), the present study failed to detect such movements. The disappearance of one-year-old fish during June and July, and the decrease in catch-per-unit-effort for young-of-the-year in late summer, suggests movement on the part of these age groups. However, the absence of these fish from samples taken in the Delta study area suggests that they move upstream within the Athabasca or into tributaries within the Mildred Lake study area.

5.2.10.6 Food habits. Examination of stomach contents showed lake chub to have fed mainly on immature stages of aquatic insects. Chironomid larvae occurred in 66% of all stomachs examined while Ephemeroptera nymphs were found in 37%. Other food items included Trichoptera, Plecoptera, Hemiptera, Hymenoptera, Coleoptera, Hydracarina, and fish remains.

5.2.11 Spottail Shiner

5.2.11.1 Distribution and relative abundance. Spottail shiners, although occurring throughout the Mildred Lake study area, were not captured in large numbers in that area during either year of the study. Over two years, spottails were captured in 20% of all small mesh seine hauls and accounted for 2% of the total catch in that gear within the upper study area. Shiners were apparently much more abundant in the Delta study area where they were taken in 58% of all hauls and made up 4% of the total catch in small mesh seines.

Samples from the Delta study area showed spottail shiners to be very abundant in June and early July (Figure 13) when one- and two-year-olds dominated the catch. Catch-per-unit-effort decreased in late July but rose again in August with the appearance of young-of-the-year.

5.2.11.2 Age and growth. Spottail shiners from the Athabasca River ranged in fork length from 14 to 97 mm. Age 1 and 2 fish (31 to 89 mm F.L.) dominated the catch in the early part of the year while young-of-the-year (14 to 46 mm F.L.) made up most of the catch during late summer and fall.

Otolith ages obtained from 306 spottail shiners varied from 0+ to 3 years. Three years appears to be the maximum age attained by spottail shiners in the AOSERP area although few live beyond age 2.

5.2.11.3 Sex and maturity. Spottail shiners in the study area become sexually mature for the first time at age 2. Seventy percent of females and 80% of males examined were mature at this age. The smallest mature shiners examined were in the 65 to 69 mm size class.

5.2.11.4 Spawning. Spottail shiners taken in June 1977 were near ripe, and spawning, although, not observed, is believed to have occurred during late June and early July. The first young-of-the-year was taken on 15 July 1977 but this age class was not common until mid-August.

The spawning population consisted largely of two-year-old fish and the paucity of fish of this age in samples taken after mid-July is believed to indicate that post-spawning mortality is severe.

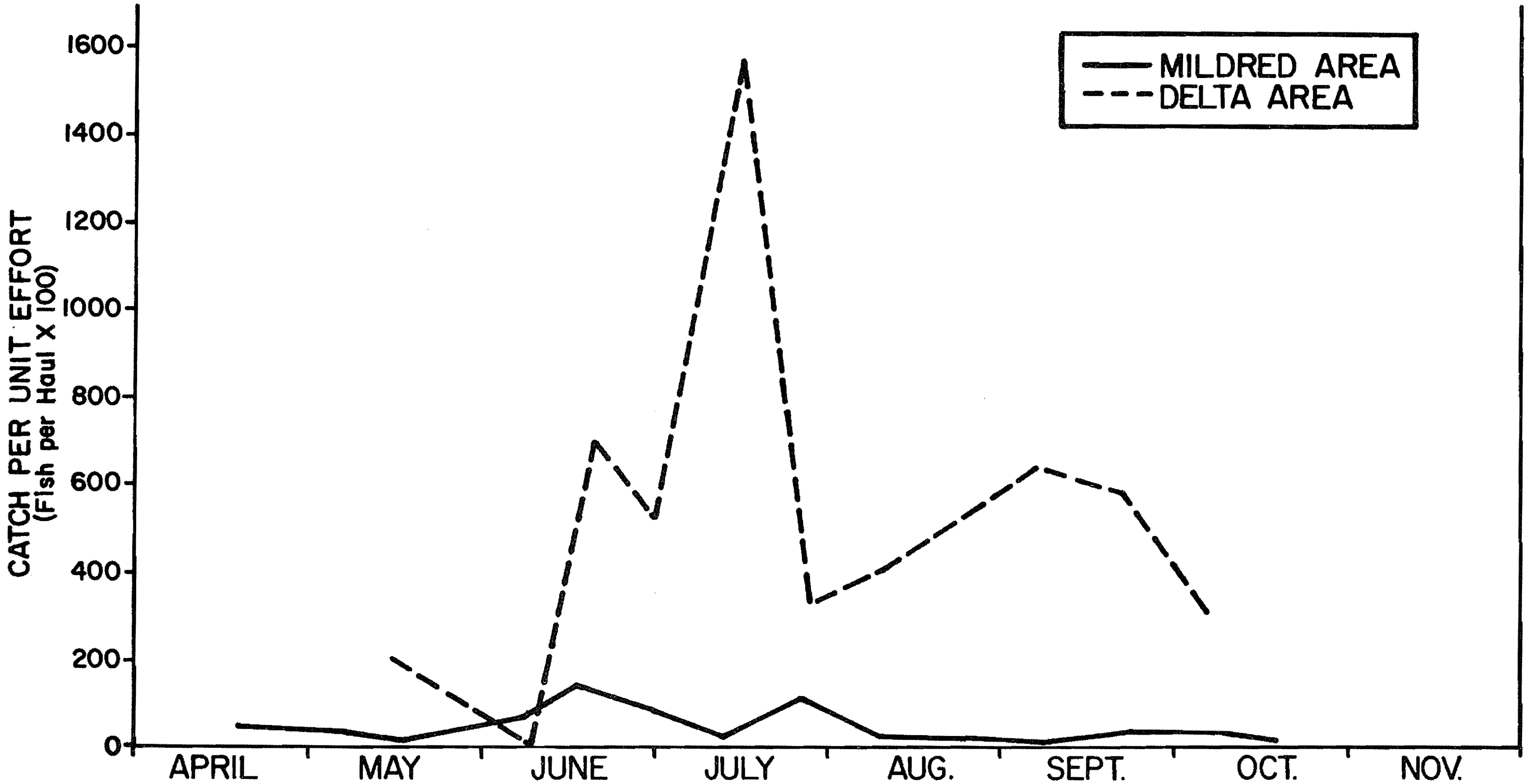

Figure 13. Seasonal changes in catch-per-unit-effort for spottail shiners captured in small mesh beach seines in the Mildred Lake and Delta study areas of the Athabasca River, 1977.

5.2.11.5 Migrations and movements. No information is available concerning movements of individual fish. However, catch-per-unit-effort values (Figure 13) suggest a movement of one-year-old (immature) and two-year-old fish (spawners) into the Delta study area during late June. Decreasing catch-per-unit-effort values in October and the paucity of one-year-olds in the Delta study area in May and early June suggest that overwintering occurs outside of the Delta study area, possibly in Lake Athabasca.

5.2.11.6 Fecundity. Total egg counts were made for 12 fully mature female spottail shiners captured from the Mildred Lake study area between 16 and 19 June 1977. These fish were all two-year-olds and measured 65 to 89 mm in fork length. Egg counts varied from 746 to 1 384 with a mean of 1 088 ova per female.

5.2.11.7 Food habits. Analysis of stomach contents showed that spottail shiners had fed predominantly on immature aquatic insects of the orders Diptera, Trichoptera, Ephemeroptera, and Plecoptera. Other food items included Cladocera, Copepoda, Ostracoda, and plant matter.

5.2.12 Other Species

Sixteen species of fish were captured that appear to be uncommon or rare in the AOSERP portion of the Athabasca River downstream from Fort McMurray during the open-water period. All of these species were represented in collections made in the Mildred Lake study area while only seven were taken in the Delta study area. With the exception of burbot (N = 146) and yellow perch (N = 402), all were represented in the collections by fewer than 75 specimens, making life history descriptions impractical.

Eight of these species appear to be truly uncommon or rare within the study area, i.e., Dolly Varden, finescale dace, northern redbelly dace, fathead minnow, ninespine stickleback, spoonhead sculpin, Iowa darter, and brassy minnow.

Six species, although rarely captured in the study area during the summer, are common in tributaries of the AOSERP area at that time. These include brook stickleback, slimy sculpin, pearl dace, longnose dace, Arctic grayling, and mountain whitefish. The first four species appear to be typically tributary species while the latter two utilize the tributary streams on a seasonal basis.

5.2.12.1 Mountain whitefish. Only 17 mountain whitefish were taken during the study, of which just two were captured downstream of the Muskeg River (Figure 1). The movements of mountain whitefish, however, are known to be quite complex and it is clear from studies on the Muskeg River (Bond and Machniak 1977) and Steepbank River (Machniak and Bond 1979) that this species is more abundant in the AOSERP area than previously supposed. These studies documented the occurrence of what are thought to be spring feeding migrations of mountain whitefish from the Athabasca River into the tributaries during late April and May. In June, these fish are thought to leave the tributaries, returning to the Athabasca River.

Spawning and overwintering areas for mountain whitefish are unknown, but probably occur in the Athabasca and Clearwater rivers upstream of Fort McMurray.

5.2.12.2 Arctic grayling. The Athabasca River is not utilized as summer habitat by Arctic grayling. However, the upper reaches of the Mildred Lake study area are important during early spring and late fall as a migration route between overwintering areas, which probably occur in the Athabasca River upstream of the study area, and spawning and summer feeding areas in tributary streams.

In late April and early May, grayling leave the Athabasca River, migrating into tributary streams where they are known to spawn. The Muskeg River (Bond and Machniak 1977, 1979) and the Steepbank River (Machniak and Bond 1979) are of major importance in this regard. After spawning, the grayling remain in the tributaries to feed, returning to the Athabasca River just prior to freeze-up. These authors believe that young-of-the-year grayling remain in the spawning stream over their first winter and do not join the migrant population until the autumn of their second year.

5.2.12.3 Dolly Varden. Dolly Varden are common in Alberta in the headwaters of the Peace, Athabasca, Red Deer, Bow, and Oldman drainages, and in the North Saskatchewan River as far downstream as Edmonton (Paetz and Nelson 1970). They are seldom found within the AOSERP area and only one specimen was captured during this study.

5.2.12.4 Northern redbelly dace. This species is known from scattered locations throughout much of Alberta (Paetz and Nelson 1970) and Griffiths (1973) reported it from the AOSERP study area.

In the present study only four specimens were captured. All were taken at tributary mouths and none was found downstream of the Muskeg River (Figure 1).

5.2.12.5 Finescale dace. Twenty-one finescale dace were taken during the study. Most of these were captured at tributary-associated sites. Finescale dace were never captured in the Delta study area and, in the Mildred Lake study area, none was found downstream of the MacKay River (Figure 1). Eight of the finescale dace captured were young-of-the-year, 11 were age 1, and two were two-year-olds. Fork lengths for these fish ranged from 21 to 58 mm. Both of the age 2 specimens, but none of the younger ones, were sexually mature.

Finescale dace are said to inhabit lakes and sluggish creeks (Paetz and Nelson 1970) and to spawn in June and July (McPhail and Lindsey 1970).

5.2.12.6 Brassy minnow. The 19 brassy minnows captured during this study represent the first reported collections of this species from the Athabasca River although its presence in the Horse River, in the Athabasca drainage, had been reported by Griffiths and Ferster (1973).

Fourteen brassy minnows were taken 19 July 1976 at the mouth of the Horse River, just upstream from Fort McMurray, while four others were captured near Fort McMurray in September 1976. A single specimen was collected 28 km downstream from Fort McMurray in mid-August 1976. These fish ranged in fork length from 44 to 66 mm. Fifteen specimens were age 1 while four were age 2. All age 2 fish were sexually mature.

5.2.12.7 Fathead minnow. Fifteen fathead minnows were captured during this study, all of which were found in the Mildred Lake study area. This species had not been identified previously from the AOSERP study area but is common to the upper Athabasca watershed (Paetz and Nelson 1970) and a few locations in Wood Buffalo National Park (Nelson and Paetz 1972, 1974). Nine of the specimens examined were immature age 1 fish. The remaining six fish were mature two-year-olds.

5.2.12.8 Longnose dace. A single longnose dace was captured in the Delta study area while 46 specimens were taken in the Mildred Lake study area over two years. All specimens were young-of-the-year or one-year-olds.

Longnose dace occur in many tributary streams in the AOSERP area (Griffiths 1973) and are more typical of the tributaries than of the Athabasca River.

5.2.12.9 Pearl dace. Only one pearl dace was captured from the Athabasca River during this study. This was a one-year-old female captured near Fort McMurray on 13 September 1976.

In the AOSERP study area, pearl dace are found in many tributaries (Griffiths 1973) where they may be extremely abundant. Machniak and Bond (1979) report that, in the Steepbank River, pearl dace accounted for 31% of all fish captured in small mesh seines (excluding suckers).

5.2.12.10 Burbot. In 1976, only 16 burbot were captured. Most of these were taken in June and the ease with which they were captured using angling gear suggested that they were common at that time. A total of 53 burbot were captured in the Mildred Lake study area in 1977. Large burbot [220 to 750 mm total length (T.L.)] were common in this area between 17 April and 19 May, after which date few large burbot were captured. Young-of-the-year (N = 10), taken in small mesh seines during June, ranged from 22 to 44 mm in total. Two burbot fry, captured in a drift net on 6 June, had total lengths of 16 and 26 mm.

In the Delta study area, 77 burbot were captured. Of this number, 73 were young-of-the-year (21 to 52 mm T.L.) taken between 7 June and 2 July.

The presence of large burbot in the Mildred Lake study area in the early spring and the appearance of young-of-the-year in early June strongly suggest that burbot utilize the Mildred Lake area of the Athabasca River, or areas upstream of it , for spawning purposes.

By mid-June, large burbot leave the Mildred Lake study area. Since the optimal temperature for this species is 15.6° to 18.3°C (Scott and Crossman 1973), it is probable that most of these burbot migrate to Lake Athabasca for the summer.

A small number of burbot are known to have entered the Steepbank River in 1977 and to have remained in that tributary until fall when 43 were captured in a downstream trap (Machniak and Bond 1979).

5.2.12.11 Brook stickleback. Only 11 brook stickleback were taken during the present study, 10 of which were found in the Mildred Lake study area.

While seldom captured in the Athabasca River, this species is widely distributed in the tributary streams of the AOSERP area (Griffiths 1973). It is known to be abundant in the upper reaches of the Muskeg River (Bond and Machniak 1977, 1979), the Steepbank

River (Machniak and Bond 1979), and the MacKay River (Machniak et al. in prep.).

5.2.12.12 Ninespine stickleback. Ninespine stickleback are rarely found either in the Athabasca River or in tributary streams of the AOSERP area. Only six were captured during this study, four in the Mildred Lake study area and two in the Delta study area.

5.2.12.13 Yellow perch. Yellow perch are known to inhabit many lakes and streams of the Athabasca River drainage, including the Ells and Christina rivers within the AOSERP study area (Paetz and Nelson 1970).

In the two years of this study, 402 yellow perch were captured, of which only 25 were taken in the Delta study area. Ninety-nine percent of all perch captured were young-of-the-year (25 to 59 mm F.L.), suggesting that these fish drifted into the study area from upstream locations and do not represent a resident population.

Young-of-the-year perch first appear in the Mildred Lake study area in late June. They are common near tributary mouths during July and August. The combined samples for the two years of the study indicate that yellow perch were taken in 50% of all small mesh seine hauls made during August and comprised 8% of the total catch during that month. After August, few perch were captured.

5.2.12.14 Iowa darter. This species is known from a few tributaries of the Athabasca River and dense populations have been found in two lakes in Wood Buffalo National Park (Nelson and Paetz 1972, 1974). Within the project study area, however, the species is rare with only a single specimen being taken during the present study. This fish measured 35 mm in total length and was captured 19 August at km 126.4 of the Athabasca River.

5.2.12.15 Slimy sculpin. Only 34 slimy sculpins were captured during the study, all of which occurred in the Mildred Lake study area.

Although apparently rare within the Athabasca River, this species is widely distributed in the tributary streams of the AOSERP study area (Griffiths 1973).

5.2.12.16 Spoonhead sculpin. Seventy-five spoonhead sculpins were captured during the study, 26 being taken in the Delta study area. Young-of-the-year (14 to 39 mm T.L.) accounted for 93% of all spoonheads captured while the remainder were one-year-olds (47 to 67 mm T.L.).

The biology of this species is poorly understood. McPhail and Lindsey (1970) state that, despite having a wide distribution and occupying a diversity of habitats, it is seldom found in abundance. They suggest that spoonheads may be common in deep areas of large turbid rivers where little sampling has occurred.

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7. AOSERP RESEARCH REPORTS

1.		AOSERP First Annual Report, 1975
2.	AF 4.1.1	Walleye and Goldeye Fisheries Investigations in the Peace-Athabasca Delta--1975
3.	HE 1.1.1	Structure of a Traditional Baseline Data System
4.	VE 2.2	A Preliminary Vegetation Survey of the Alberta Oil Sands Environmental Research Program Study Area
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7.	AF 3.1.1	A Synopsis of the Physical and Biological Limnology and Fisheries Programs whithin the Alberta Oil Sands Area
8.	AF 1.2.1	The Impact of Saline Waters upon Freshwater Biota (A Literature Review and Bibliography)
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15.	ME 3.4	A Climatology of Low Level Air Trajectories in the Alberta Oil Sands Area
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20.	HY 3.1.1	Characterization of Organic Constituents in Waters and Wastewaters of the Athabasca Oil Sands Mining Area
21.		AOSERP Second Annual Report, 1976-77
22.		Alberta Oil Sands Environmental Research Program Interim Report to 1978 covering the period April 1975 to November 1978
23.	AF 1.1.2	Acute Lethality of Mine Depressurization Water on Trout Perch and Rainbow Trout
24.	ME 1.5.2	Air System Winter Field Study in the AOSERP Study Area, February 1977.
25.	ME 3.5.1	Review of Pollutant Transformation Processes Relevant to the Alberta Oil Sands Area

26. AF 4.5.1 Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
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31. VE 2.3 Ecological Habitat Mapping of the AOSERP Study Area: Phase I
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33. TF 1.2 Relationships Between Habitats, Forages, and Carrying Capacity of Moose Range in northern Alberta. Part I: Moose Preferences for Habitat Strata and Forages.
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45. VE 3.3 Interim Report on Physiology and Mechanisms of Air-Borne Pollutant Injury to Vegetation, 1975 to 1978
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47. TF 1.1.1 A Visibility Bias Model for Aerial Surveys for Moose on the AOSERP Study Area
48. HG 1.1 Interim Report on a Hydrogeological Investigation of the Muskeg River Basin, Alberta
49. WS 1.3.3 The Ecology of Macrobenthic Invertebrate Communities in Hartley Creek, Northeastern Alberta
50. ME 3.6 Literature Review on Pollution Deposition Processes
51. HY 1.3 Interim Compilation of 1976 Suspended Sediment Date in the AOSERP Study Area
52. ME 2.3.2 Plume Dispersion Measurements from an Oil Sands Extraction Plan, June 1977

53. HY 3.1.2 Baseline States of Organic Constituents in the Athabasca River System Upstream of Fort McMurray
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55. HY 2.6 Microbial Populations in the Athabasca River
56. AF 3.2.1 The Acute Toxicity of Saline Groundwater and of Vanadium to Fish and Aquatic Invertebrates
57. LS 2.3.1 Ecological Habitat Mapping of the AOSERP Study Area (Supplement): Phase I
58. AF 2.0.2 Interim Report on Ecological Studies on the Lower Trophic Levels of Muskeg Rivers Within the Alberta Oil Sands Environmental Research Program Study Area
59. TF 3.1 Semi-Aquatic Mammals: Annotated Bibliography
60. WS 1.1.1 Synthesis of Surface Water Hydrology
61. AF 4.5.2 An Intensive Study of the Fish Fauna of the Steepbank River Watershed of Northeastern Alberta
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67. WS 1.3.2 Aquatic Biological Investigations of the Muskeg River Watershed
68. AS 1.5.3 AS 3.5.2 Air System Summer Field Study in the AOSERP Study Area, June 1977
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70. LS 28.1.2 An Interim Report on the Insectivorous Animals in the AOSERP Study Area
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77. HS 20.1 Overview of Local Economic Development in the Athabasca Oil Sands Region Since 1961.
78. LS 22.1.1 Habitat Relationships and Management of Terrestrial Birds in Northeastern Alberta

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86. AS 3.7 An Observational Study of Fog in the AOSERP Study Area.
87. WS 2.2 Hydrogeological Investigation of Muskeg River Basin, Alberta

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