PRODUCTION POTENTIAL OF SOCKEYE SALMON NURSERY LAKES IN SOUTHERN SOUTHEAST ALASKA

By

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ABSTRACT

Potential sockeye *Oncorhynchus nerka* salmon production for 112 anadromous lake systems in southern Southeast Alaska were calculated using an euphotic volume model developed by Koenings and Burkett (1987). Physical parameters used in this model were collected or estimated, from known values of similar lakes, for 112 lakes identified in Alaska Department of Fish and Game (ADF&G), commercial fisheries management districts 101 through 108. Compilation of all data, using this model, indicated that southern Southeast Alaska sockeye lakes have the estimated potential to produce 1.714 million adult sockeye. This production would allow 1.097 million harvestable adults with the remaining 0.617 million adults needed for escapement to maintain the maximum production. The intent of this study was to provide fisheries managers with a basic mechanism to quantify escapement and harvest goals for individual systems, subdistricts, or entire districts.

KEY WORDS: sockeye, *Oncorhynchus nerka*, Southeast Alaska, euphotic volume model, production potential model, salmon, escapement goals, harvest goals, maximum production, morphometry, euphotic zone

INTRODUCTION

Sockeye *Oncorhynchus nerka* salmon rehabilitation and enhancement programs in the state of Alaska have been ongoing since 1979. Numerous investigations have been directed toward defining relationships between limnological parameters and sockeye salmon rearing capacities (Koenings and Burkett 1987; Koenings, et al. 1989; Peltz and Koenings 1989). An euphotic volume model (Koenings and Burkett 1987) emerged from these studies as a rudimentary method to quantify the optimum sockeye salmon adult production goal; under the assumption that the limiting life history stage for sockeye is their juvenile freshwater life phase. This is the first known effort to quantify the sockeye salmon production potential of southern Southeast Alaska (Figure 1). Limitations in the physical habitat required for other life history phases were not considered in these production estimates. These data will hopefully help direct enhancement or rehabilitation programs as well as management decisions in fulfilling sockeye salmon production goals.

METHODS

Production Model

The juvenile sockeye rearing capacity estimates are based on an euphotic volume model developed by Koenings and Burkett (1987). Calculated as follows:

$$[\text{Lake Surface Area } (m^2) \bullet \text{EZD } (m)] \bullet 1{,}000{,}000^{-1} = \text{EV units}$$

The euphotic zone depth (EZD), the depth to which 1% of the subsurface light [photosynthetically available radiation (400-700 nm)] penetrates (Schindler 1971), is calculated as the y-intercept derived by regressing depth against the logarithm (ln) of the percent subsurface light. Euphotic volume (EV) is the product of the euphotic zone depth (EZD) and the lake surface area and represents the volume of water capable of photosynthesis. One euphotic volume (EV) unit is equal to one million cubic meters of water (Figure 2). This EV model is based on a set of empirical models that provide estimates of potential

juvenile and adult sockeye production. According to the model, one EV unit can sustain a maximum of 110,000 spring fry, which will produce 23,000 threshold size (2.2 g) smolt and 2,500 adult sockeye.

Analysis and Evaluation

Each lake system in this report was first identified by a group of inter-departmental biologists from the ADF&G and the National Marine Fisheries Service (NMFS) as an anadromous sockeye system. After this initial identification a complete search of data and reports for each lake was accomplished. Data were unavailable for most of the smaller sockeye salmon lakes.

Lake Area

Lake surface areas were measured using the most accurate means possible in the following order:

1. Actual lake surveys where bathymetric maps were created using depth soundings and ground measurements between prominent points. These measurements were then scaled down to drawings made from aerial photos.
2. Digitized computer analysis of aerial photos and landsat photos by the USDA - Forest Service Geographical Information System (GIS).

The lake surface areas in this report should supersede surface areas from previously reported data. Many older ADF&G, Sport Fish Division lake surveys[2] include lake surface areas which were merely visual estimates.

Lake Productivity

Productivity was evaluated using euphotic zone depth (EZD) which is an index of limnetic production (Koenings and Burkett 1987). Dependent on the frequency of lake limnological sampling, the most accurate means possible was used to calculate EZD. The following order represents the degree of accuracy from highest to lowest.

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[2] Baade, R., et al., Alaska Dept. of Fish and Game, Sport Fish Division. SE Alaska Lake surveys. Unpublished.

1. Submarine photometer to measure actual incidental light levels in the water column. Usually taken throughout the year during normal limnological sampling programs. Mean of seasonal readings used for EZD.

2. Secchi disk transparency readings (SD), using a 20 cm black and white disk, usually taken during one preliminary lake survey. SD readings are converted to EZD by regression analysis for each lake type (clear or stained) (Koenings, et.al. 1987).

3. No actual lake surveys. Lake was assigned a weighted mean EZD based on known water color of the lake. The EZD assigned are weighted means based on thirty stained and five clear lakes in southern Southeast Alaska with actual data. The mean EZD is calculated as follows:

$$\overline{EZD} = \frac{\sum SA_i (EZD_i)}{\sum SA_i}$$

Where: SA_i = surface area of individual lake (i)
EZD_i = euphotic zone depth of individual lake (i)

Lakes were differentiated as stained or clear for formula. Calculated values are: Stained = 5.0 m; Clear = 11.0 m.

Adult Production

The final intent of this paper is to estimate the potential production of adult sockeye salmon from each system for escapement and harvest. The escapement goal is the fixed number of fish required to sustain maximum adult production based on this model. The escapement goal based on the EV Model is 800 to 900 adults per EV unit (Koenings and Burkett 1987). This is a minimum required escapement. Geiger and Koenings (1991) escapement goal model calculated that Chilkat Lake, in northern Southeast Alaska, has a best escapement value based on actual spawner/ recruitment data of 1,290 adults per EV unit. For our purposes we used 900 adults per EV unit.

RESULTS

A total of 112 lakes in southern Southeast Alaska (Districts 101-108), were identified as current sockeye salmon producing systems (Table 1). Total potential adult sockeye production was estimated to be 1.714 million fish. The estimated minimum escapement goal is 617,152 to sustain maximum yields. This would allow for a potential annual harvest of approximately 1,097,161 sockeye.

Twenty lakes in District 101 have an estimated potential to produce 353,444 adults (Table 2). This would allow 226,204 adults for harvest and 127,240 for escapement. The largest potential producers in District 101 are the Bakewell Lake system (84,639 adults), McDonald Lake (83,980 adults) and Hugh Smith Lake (43,986 adults). Historically, in the late 1800's, Hugh Smith, Naha, and McDonald were the largest producers of sockeye. Hugh Smith produced more than 60,000 harvestable fish during this period; Naha averaged over 53,000 and McDonald averaged over 50,000 (Moser 1899). The Bakewell system was a non-anadromous system until 1958 when a fish pass was constructed.

Twenty-four lakes in District 102 have an estimated potential to produce 336,302 adults (Table 3). This would allow 215,233 adults for harvest and 121,069 adults for escapement. The largest potential producers in District 102 are Karta River system (95,057), Kegan Lake (66,113), Thorne River system (56,078), and Miller Lake (44,224). Historically the Karta River system was the largest producer with a harvest over 100,000 in 1906 (Moser, et al. 1907). Other historically large producers are Thorne River system, Paul Lake, Johnson Lake, and Kegan Lake all producing more than 30,000 adults in the late 1800's (Moser 1899).

Thirty-eight lakes in District 103 have an estimated potential to produce 374,289 adults (Table 4). This would allow 239,546 adults for harvest and 134,743 adults required for escapement. The largest potential producers for District 103 are Klawock Lake (123,549), Sarkar system (98,425), and Hetta Lake (70,943). District 103 has the highest production potential of all districts in this report. Historically, Hetta Lake was the largest sockeye producer in this district averaging more than 60,000 with a peak of 201,299 in the late 1800's. During this time Klawock Lake averaged 36,000, Sarkar averaged 16,000, and Klakas averaged 7,000 (Moser 1899).

Six lakes in District 104 have an estimated potential to produce 172,884 adults (Table 5). This would allow 110,645 adults for harvest and 62,239 adults for escapement. The largest producer in District 104

are the Devils Lake Head system (87,186) and Essowah Bay system (52,334). There are no historical records from this district before 1960 primarily because the area was not close to operating canneries.

Four lakes in District 105 have an estimated potential to produce 35,126 adults (Table 6). This would allow 22,481 adults for harvest with 12,645 adults needed for escapement. This is the lowest production district in southern Southeast Alaska. The largest producer in District 105 is Shipley Lake (22,877). Historically, Shipley Lake was the highest producer in the late 1800's with a peak of 6,762 adults harvested in 1892. These numbers are misleading because this system was not used for cannery operations because it was off the path of cannery steamers. These fish were primarily sold salted via a saltery located on site and sold only when the mail steamer came about (Moser 1898).

Fourteen lakes in District 106 have an estimated potential to produce 357,033 adults (Table 7). This would allow 228,502 adults for harvest and 128,531 adults required for escapement. The largest producers in District 106 are Sweetwater system (149,612), Salmon Bay Lake (47,053), and Red Bay Lake (45,174). The Sweetwater Lake system potential production is questionable because Sweetwater Lake, which is the largest lake in the system, receives salt water during high tides. The extent of this influence is unknown concerning limnetic production of this lake. Historically, Salmon Bay and Red Bay Lakes were the largest producers with annual harvests above 50,000 and 20,000 respectively in the late 1800's to early 1900's (Moser et al. 1898-1910).

Six lakes in District 107 have an estimated potential to produce 85,235 adult sockeye (Table 8). This would allow 54,550 adults for harvest and would require 30,685 adults for escapement. The largest producer in District 107 is Virginia Lake (48,819). Thoms Lake historically was the largest producer with a harvest of 17,138 in 1897 (Moser 1898).

There are no lakes in District 108. The Stikine River system (U.S. portion) in District 108 produces sockeye but cannot be evaluated with the Euphotic Volume Model.

DISCUSSION

This report presents only relative production potential estimates for each lake based on lake morphological data. Possible limitations in spawning habitat were not considered in these production estimates. A more detailed habitat analysis of the individual systems will be necessary to identify any such limitations. Harvest rates on certain southern Southeast Alaska systems have been as high as 97% (Badger-Bakewell system, 1991) of the total yearly production. These systems are unlikely to reach their production goals without changes in harvest strategies. With further data collection and analysis a more accurate estimate of production potential will result. The early historical sockeye counts by Moser et al. (1898-1910) were based on harvest numbers for individual streams, and provided total stream counts since most streams were blocked to upstream passage so all fish could be harvested. This was the period for large harvests of sockeye in southern Southeast Alaska.

Nutrient enrichment of certain lakes has also increased production dramatically. McDonald Lake has been receiving nutrient enrichment since 1982, and production has increased from an estimated average of 84,000 adults to an excess of 300,000 adults annually. The enrichment program has allowed McDonald Lake to sustain a rearing capacity which is substantially higher than prior to enrichment. Annual production from McDonald Lake, with nutrient enrichment, contributes roughly 7.5 percent of the total SSE Alaska districts 101-108 commercial harvest.

These data will hopefully help direct enhancement and/or rehabilitation programs as well as management strategies toward reaching full production potential.

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Table 1. Total potential sockeye salmon production from southern Southeast Alaska anadromous lakes in Districts 101-108 based on the euphotic volume model.

District Totals	Lakes	Surface Area ($m^2 \cdot 10^6$)	Weighted Mean Euphotic Depth EZD (m)	Euphotic Volume Units	Spring Fry Capacity (Millions)	Total Smolt	Total Adults	Escapement Goal	Harvestable Adults
District 101	20 Lakes	22.163	6.4	141.4	15.552	3,251,686	353,444	127,240	226,204
District 102	24 Lakes	21.437	6.3	134.5	14.797	3,093,966	336,302	121,069	215,233
District 103	38 Lakes	30.646	4.9	149.7	16.469	3,443,450	374,289	134,743	239,546
District 104	6 Lakes	8.685	8.0	69.2	7.607	1,590,546	172,884	62,239	110,645
District 105	4 Lakes	2.810	5.0	14.1	1.546	323,157	35,126	12,645	22,481
District 106	14 Lakes	24.331	5.9	142.8	15.709	3,284,713	357,033	128,531	228,502
District 107	6 Lakes	5.414	6.3	34.1	3.750	784,164	85,235	30,685	54,550
Grand Totals For Districts 101-108	**112 Lakes**	**115.486**	**5.9**	**685.7**	**75.430**	**15,771,712**	**1,714,313**	**617,152**	**1,097,161**

Table 2. Potential sockeye salmon production from southern Southeast Alaska anadromous lakes in District 101 based on the euphotic volume model.

System	ADF&G Stream #	Lakes	Surface Area ($m^2 \cdot 10^6$)	Mean(EZD) Euphotic Depth (m)	Euphotic Volume Units	Spring Fry Capacity (millions)	Total Smolt (millions)	Total Adults	Escapement Goal	Maximum Recorded Escapement	Harvestable Adults
Bakewell River	101-55-073	Badger / Bakewell	5.001 a/	4.5&9.9c/	33.8	3.724	0.779	84,639	30,470	2,165 (1992) e/	54,169
McDonald	101-80-068	McDonald	4.199 a/	8.0 c/	33.6	3.695	0.773	83,980	30,233	174,910 (1991) f/	53,747 j/
Hugh Smith	101-30-075	Hugh Smith	3.199 a/	5.5 c/	17.6	1.935	0.405	43,986	15,835	209,799 (1907) g/	28,151
Naha River	101-90-050	Jordon / Heckman	2.158 b/	6.0&6.1c/	13.1	1.442	0.301	32,769	11,797	150,000 (1948) h/	20,972
Mahoney Creek	101-45-016	Mahoney	0.644 b/	11.0 d/	7.1	0.779	0.163	17,705	6,374	15,000 (8/08/56) i/	11,331
Checats Creek	101-51-005	Lower Checats	1.101 b/	5.0 d/	5.5	0.606	0.127	13,767	4,956	19,821 (1898) h/	8,811
Leask Creek	101-45-032	2 Lakes	1.024 b/	5.0 d/	5.2	0.563	0.118	12,805	4,610	2,500 (1987) i/	8,195
Fillmore Creek	101-11-079	Shrew	0.429 b/	11.0 d/	4.7	0.519	0.109	11,803	4,249	9,000 (8/26/56) i/	7,554
Kah Shakes Creek	101-23-010	Kah Shakes	0.790 b/	5.0 d/	4.0	0.435	0.091	9.875	3,555	8,000 (1897) h/	6,320
Unuk River	101-75-030	Gene's	0.781 b/	5.0 d/	3.9	0.430	0.090	9,768	3,517	634 (8/13/83)i/	6,251
Sockeye Creek	101-11-039	Nakat	0.696 b/	5.0 d/	3.5	0.383	0.080	8,706	3,134	29,983 (1908) e/	5,572
Marguerite Creek	101-90-039	Margaret	0.555 b/	5.8 c/	3.2	0.354	0.074	8,043	2,896	322 (1992) e/	5,147
Helm Bay	101-90-084	Helm	0.846 b/	2.5 c/	2.1	0.233	0.049	5,289	1,904	60,041 (1909) g/	3,385
George Inlet Creek	101-45-038	Left Fork	0.247 b/	5.0 d/	1.2	0.136	0.028	3,087	1,111		1,976
Ward Creek	101-47-015	Ward	0.142 a/	8.0 c/	1.1	0.125	0.026	2,840	1,022	1,950 (1906) h/	1,818
Lucky Cove Creek	101-41-025	Lower	0.211 b/	5.0 d/	1.1	0.116	0.024	2,632	947		1,685
Fish Creek	101-43-033	Low	0.139 b/	5.0 d/	0.7	0.077	0.016	1,750	630	400 (9/19/49)i/	1,120
Totals		**20 Lakes**	**22.163**		**141.4**	**15.552**	**3.252**	**353,444**	**127,240**		**226,204**
Weighted mean				**6.4**							

a/ Area calculated using ground measurements, aerial photos and polar planimeter.
b/ Surface area obtained from USDA Forest Service Geographical Information System (GIS) lake layer; Ketchikan Area, Tongass National Forest.
c/ EZD depth taken from mean 1% light readings from submarine photometer.
d/ Identified water type and then assigned a weighted mean EZD value by lake color.
e/ Total annual weir counts.
f/ Yearly total based on escapement counts.
g/ Taken from cannery records at this system. Could include fish delivered from nearby lake systems.
h/ Data obtained from Moser, et al., U.S. Fish Commission Reports. 1899-1960.
i/ Single escapement count. ADF&G, Commercial Fish Division Annual Reports. 1961-1989.
j/ Since 1982 McDonald Lake has been receiving fertilizer. This nutrient application has sustained higher numbers than those listed, based on euphotic volume. To sustain high numbers: 1. fertilizer must continue; 2. Escapement goal is 85,000. This would leave an estimated 60,000 to 300,000 harvestable adults.

Table 3. Potential sockeye salmon production from southern Southeast Alaska anadromous lakes in District 102 based on the euphotic volume model.

System	ADF&G Stream #	Lakes	Surface Area ($m^2 \cdot 10^6$)	Mean(EZD) Euphotic Depth (m)	Euphotic Volume Units	Spring Fry Capacity (millions)	Total Smolt (millions)	Total Adults	Escapement Goal	Maximum Recorded Escapement	Harvestable Adults
Karta River	102-60-087	Karta / Salmon	6.843 b/	3.0 & 6.0c/	38.0	4.182	0.874	95,057	34,220	107,061 (1906) e/	60,837
Kegan Cove	102-30-067	Kegan	2.543 b/	10.4 c/	26.4	2.909	0.608	66,113	23,801	29,775 (1896) f/	42,312
Thorne River	102-70-058	9 Lakes	4.487 b/	5.0 d/	22.5	2.468	0.516	56,078	20,189	35,516 (1890) f/	35,889
Miller Creek	102-30-089	Miller	1.393 b/	12.7 c/	17.7	1.946	0.407	44,224	15,921	36,934 (1897) f/	28,303
Dolomi Creek	102-20-040	Paul	1.506 b/	6.6 c/	9.9	1.094	0.229	24,853	8,947	33,372 (1914) f/	15,906
Nichols Creek	102-10-060	Nichols	1.535 b/	2.6 c/	4.0	0.439	0.092	9,975	3,591	31,192 (1896) f/	6,384
Johnson Cove	102-30-017	Johnson	0.765 b/	5.0 c/	3.8	0.421	0.088	9,566	3,444	15,558 (1895) f/	6,122
Dora Bay	102-40-033	Dora	0.587 b/	5.0 d/	2.9	0.323	0.068	7,339	2,642	9,000 (1897) f/	4,697
Dog Salmon Creek	102-60-038	Dog Salmon	0.434 a/	5.8 c/	2.5	0.277	0.058	6,293	2,265	50 (1983) g/	4,028
Salt Chuck	102-60-095	Ellen / Lake #3	0.376 b/	5.0 d/	1.9	0.208	0.043	4,707	1,694	50 (1983) g/	3,013
Old Tom's Creek	102-60-024	Unnamed	0.292 b/	5.0 d/	1.5	0.160	0.034	3,644	1,312	19 (1977) g/	2,332
Saltery Cove	102-60-005	Unnamed	0.255 b/	5.0 d/	1.3	0.140	0.029	3,189	1,148		2,041
Kina Cove	102-60-068	Kina	0.235 b/	5.0 d/	1.2	0.129	0.027	2,936	1,057	2,018 (1896) f/	1,879
Cabin Creek	102-60-042	Unnamed	0.186 b/	5.0 d/	0.9	0.102	0.021	2,328	838		1,490
Totals		**24 Lakes**	**21.437**		**134.5**	**14.797**	**3.094**	**336,302**	**121,069**		**215,233**
Weighted mean				**6.3**							

a/ Area calculated using ground measurements, aerial photos and polar planimeter.
b/ Surface area obtained from USDA Forest Service Geographical Information System (GIS) lake layer; Ketchikan Area, Tongass National Forest.
c/ EZD depth taken from mean 1% light readings from submarine photometer.
d/ Identified water type and then assigned weighted mean EZD value by lake color.
e/ Taken from cannery records at this system. Could include fish delivered from nearby lake systems.
f/ Data obtained from Moser, et al., U.S. Fish Commission Reports. 1899-1960.
g/ Single escapement count. ADF&G, Commercial Fish Division Annual Reports 1961-1989.

Table 4. Potential sockeye salmon production from southern Southeast Alaska anadromous lakes in District 103 based on the euphotic volume model.

System	ADF&G Stream #	Lakes	Surface Area ($m^2 \cdot 10^6$)	Mean(EZD) Euphotic Depth (m)	Euphotic Volume Units	Spring Fry Capacity (millions)	Total Smolt (millions)	Total Adults	Escapement Goal	Maximum Recorded Escapement	Harvestable Adults
Klawock River	103-60-047	Klawock	11.767 a/	4.2 d/	49.4	5.436	1.137	123,549	44,478	65,314 (1936) g/	79,071
Sarkar	103-90-014	13 Lakes	9.928b/c/	2.0-5.0d/f/	39.4	4.330	0.905	98,425	35,433	55,000 (9/30/55)h/	62,992
Hetta Inlet	103-25-047	Hetta	2.425 b/	11.7 d/	28.4	3.121	0.653	70,943	25,539	201,299 (1896) h/	45,404
Klakas Inlet	103-15-027	Klakas	1.802 b/	5.3 f/	9.5	1.050	0.220	23,874	8,595	23,330 (1897) h/	15,279
Hunter Bay	103-11-017	3 Lakes	1.284 b/	5.0 e/	6.4	0.705	0.148	16,045	5,776	7,618 (1896) h/	10,269
Warm Chuck Creek	103-80-031	Chuck	0.628 b/	4.0 f/	2.5	0.276	0.058	6,276	2,259	8,000 (1956) h/	4,017
Tunga Lagoon	103-90-009	Unnamed	0.462 b/	5.0 e/	2.3	0.254	0.053	5,770	2,077	30,000 (1958) h/	3,693
Eek Creek	103-25-009	Eek	0.393 b/	5.0 e/	2.0	0.216	0.045	4,910	1,767	9,213 (1897) h/	3,143
Black Bear Creek	103-60-031	Black	0.348 b/	5.0 e/	1.7	0.192	0.040	4,353	1,567	1,000 (1981) i/	2,786
East Head Biscuit	103-11-013	Unnamed	0.344 b/	5.0 e/	1.7	0.189	0.040	4,302	1,549		2,753
Karheen Creek	103-90-093	3 Lakes	0.328 b/	5.0 e/	1.6	0.180	0.038	4,100	1,476		2,624
Kasook	103-40-058	Kasook	0.279 b/	5.0 e/	1.4	0.154	0.032	3,492	1,257	2,415 (1897) h/	2,235
Nutkwa Creek	103-21-008	Small	0.215 b/	5.0 e/	1.1	0.118	0.025	2,683	966	14,000 (8/26/71)i/	1,717
Naukati Creek	103-90-026	7 Lakes	0.186 b/	5.0 e/	0.9	0.102	0.021	2,328	838		1,490
Keete Inlet	103-21-018	Unnamed	0.170 b/	5.0 e/	0.9	0.094	0.020	2,126	765	247 (1986) i/	1,361
Tokeen Bay	103-90-069	Unnamed	0.089 b/	5.0 e/	0.4	0.049	0.010	1,113	401	25 (1982) i/	712
Totals		**38 Lakes**	**30.646**		**149.7**	**16.469**	**3.443**	**374,289**	**134,743**		**239,546**
Weighted mean				**4.9**							

a/ Area calculated using ground measurements, aerial photos and polar planimeter.
b/ Surface area obtained from USDA Forest Service Geographical Information System (GIS) lake layer; Ketchikan Area, Tongass National Forest.
c/ Data found in Federal Aid in Fish Restoration and Anadromous Fish Studies. Schmidt, A., et al., Alaska Department of Fish and Game; Sport Fish Division.
d/ EZD depth taken from mean 1% light readings from submarine photometer.
e/ Identified water type and then assigned weighted mean EZD value by lake color.
f/ Secchi depth converted to EZD; Regressions found in ADF&G, FRED Limnology Lab Manual, FRED Report #71, 1987. pp.23-25.
g/ Total annual weir count.
h/ Data obtained from Moser, et al., U.S. Fish Commission Reports. 1899-1960.
i/ Single escapement count. ADF&G, Commercial Fish Division Annual Reports 1961-1989.

Table 5. Potential sockeye salmon production from southern Southeast Alaska anadromous lakes in District 104 based on the euphotic volume model.

System	ADF&G Stream #	Lakes	Surface Area ($m^2 \cdot 10^6$)	Mean(EZD) Euphotic Depth (m)	Euphotic Volume Units	Spring Fry Capacity (millions)	Total Smolt (millions)	Total Adults	Escapement Goal	Maximum Recorded Escapement	Harvestable Adults
Devils Lake Head	104-20-030	2 Lakes	3.170 a/	11.0 b/	34.9	3.836	0.802	87,168	31,387	100 (8/10/75) c/	55,799
Essowah Bay	104-10-005	2 Lakes	4.187 a/	5.0 b/	20.9	2.303	0.481	52,334	18,841	20 (8/30/76) c/	33,493
Welcome Creek	104-20-035	Welcome	1.118 a/	11.0 b/	12.3	1.352	0.283	30,732	11,064		19,668
Manhattan Arm	104-20-010	Unnamed	0.211 a/	5.0 b/	1.1	0.116	0.024	2,632	947	2 (1982) c/	1,685
Totals		**6 Lakes**	**8.685**		**69.2**	**7.607**	**1.591**	**172,884**	**62,239**		**110,645**
Weighted mean				**8.0**							

a/ Surface area obtained from USDA Forest Service Geographical Information System (GIS) lake layer; Ketchikan Area, Tongass National Forest.
b/ Identified water type and then assigned weighted mean EZD value by lake color.
c/ Total annual weir count.

Table 6. Potential sockeye salmon production from southern Southeast Alaska anadromous lakes in District 105 based on the euphotic volume model.

System	ADF&G Stream #	Lakes	Surface Area ($m^2 \cdot 10^6$)	Mean(EZD) Euphotic Depth (m)	Euphotic Volume Units	Spring Fry Capacity (millions)	Total Smolt (millions)	Total Adults	Escapement Goal	Maximum Recorded Escapement	Harvestable Adults
Shipley Bay	105-43-002	Shipley	1.830 a/	5.0 c/	9.2	1.007	0.210	22,877	8,236	6,762 (1892) e/	14,641
Kushneahin Creek	105-31-003	Kushneahin	0.547 b/	5.0 c/	2.7	0.301	0.063	6,833	2,460	5,000 (7/31/71) d/	4,373
Sutter Creek	105-42-014	Sutter	0.263 a/	5.0 c/	1.3	0.145	0.030	3,290	1,184	834 (9/16/82) d/	2,106
Port Beauclerc	105-20-006	Beauclerc	0.170 b/	5.0 c/	0.9	0.094	0.020	2,126	765	100 (8/18/63) d/	1,361
Totals		**4 Lakes**	**2.810**		**14.1**	**1.546**	**0.323**	**35,126**	**12,645**		**22,481**
Weighted mean				**5.0**							

a/ Surface area obtained from USDA Forest Service Geographical Information System (GIS) lake layer; Ketchikan Area, Tongass National Forest.
b/ Surface area obtained from USDA Forest Service Geographical Information System (GIS) lake layer; Stikine Area, Tongass National Forest.
c/ Identified water type and then assigned weighted mean EZD value by lake color.
d/ Single escapement count. ADF&G, Commercial Fish Division Annual Reports 1961-1989.
e/ Data taken from Moser, et al., U.S. Fish Commission Reports. 1899-1960.

Table 7. Potential sockeye salmon production from southern Southeast Alaska anadromous lakes in District 106 based on the euphotic volume model.

System	ADF&G Stream #	Lakes	Surface Area ($m^2 \cdot 10^6$)	Mean(EZD) Euphotic Depth (m)	Euphotic Volume Units	Spring Fry Capacity (millions)	Total Smolt (millions)	Total Adults	Escapement Goal	Maximum Recorded Escapement	Harvestable Adults
Sweetwater	106-30-066	4 Lakes	11.969 a/	5.0 d/	59.9	6.583	1.377	149,612	53,861		95,751
Salmon Bay	106-41-010	Salmon Bay	4.005 a/	4.7 e/	18.8	2.070	0.433	47,053	16,939	86,019 (1907) e/	30,114
Red Bay	106-41-030	Red	1.705 a/	10.6 e/	18.1	1.988	0.416	45,174	16,262	34,088 (1910) f/	28,912
Kah Sheets Creek	106-42-010	Kah Sheets	1.579 b/	11.0 d/	17.4	1.911	0.399	43,423	15,632	15,500 (1955) f/	27,791
Eagle Creek	106-10-030	Luck	2.097 a/	4.2 c/	8.8	0.969	0.203	22,023	7,928	17,414 (1931) e/	14,095
Petersburg Creek	106-44-060	Petersburg	0.729 b/	11.0 d/	8.0	0.882	0.184	20,043	7,215	30,000 (1957) f/	12,828
Ratz Harbor	106-10-010	3 Lakes	1.365 a/	5.6 c/ & d/	7.7	0.850	0.178	19,319	6,955	7,926 (1917) f/	12,364
Streets Creek	106-20-010	Streets	0.518 b/	4.5 c/	2.3	0.257	0.054	5,831	2,099		3,732
McHenry Inlet	106-21-003	Hatchery	0.364 b/	5.0 d/	1.8	0.200	0.042	4,555	1,640	22,432 (1914) f/	2,915
Totals		**14 Lakes**	**24.331**		**142.8**	**15.709**	**3.285**	**357,033**	**128,531**		**228,502**
Weighted mean				**5.9**							

a/ Surface area obtained from USDA Forest Service Geographical Information System (GIS) lake layer; Ketchikan Area, Tongass National Forest.
b/ Surface area obtained from USDA Forest Service Geographical Information System (GIS) lake layer; Stikine Area, Tongass National Forest.
c/ EZD depth taken from mean 1% light readings from submarine photometer.
d/ Identified water type and then assigned weighted mean EZD value by lake color.
e/ Taken from cannery records at this system. Could include fish delivered from nearby lake systems.
f/ Data taken from Moser, et al., U.S. Fish Commission Reports. 1899-1960.

Table 8. Potential sockeye salmon production from southern Southeast Alaska anadromous lakes in Districts 107 based on the euphotic volume model.

System	ADF&G Stream #	Lakes	Surface Area ($m^2 \cdot 10^6$)	Mean(EZD) Euphotic Depth (m)	Euphotic Volume Units	Spring Fry Capacity (millions)	Total Smolt (millions)	Total Adults	Escapement Goal	Maximum Recorded Escapement	Harvestable Adults
Mill Creek	107-40-007	Virginia	2.604 a/	7.5 b/	19.5	2.148	0.449	48,819	17,575	300 (7/30/76) e/	31,244
Thoms Creek	107-30-030	2 Lakes	1.494 a/	5.0 c/	7.5	0.821	0.172	18,676	6,723	17,138 (1897) f/	11,953
Kunk Creek	107-30-095	Kunk	0.952 a/	5.0 c/	4.8	0.523	0.109	11,894	4,282	700 (7/30/62) e/	7,612
Tom Lake Creek	107-40-047	Tom	0.142 a/	11.0 c/	1.6	0.171	0.036	3,897	1,403	500 (8/21/72) e/	1,814
Santa Anna Inlet	107-20-010	Helen	0.223 a/	3.5 d/	0.8	0.086	0.018	1,949	702		2,494
Totals		**6 Lakes**	**5.414**		**34.1**	**3.750**	**0.784**	**85,235**	**30,685**		**54,550**
Weighted mean				**6.3**							

a/ Surface area obtained from USDA Forest Service Geographical Information System (GIS) lake layer; Stikine Area, Tongass National Forest.
b/ EZD depth taken from mean 1% light readings from submarine photometer.
c/ Identified water type and then assigned weighted mean EZD value by lake color.
d/ Secchi depth converted to EZD; Regressions found in ADF&G, FRED Limnology Lab Manual, FRED Report #71, 1987, pp.23-25.
e/ Single escapement count. ADF&G, Commercial Fish Division Annual Reports 1961-1989.
f/ Data taken from Moser, et al., U.S. Fish Commission Reports. 1899-1960.

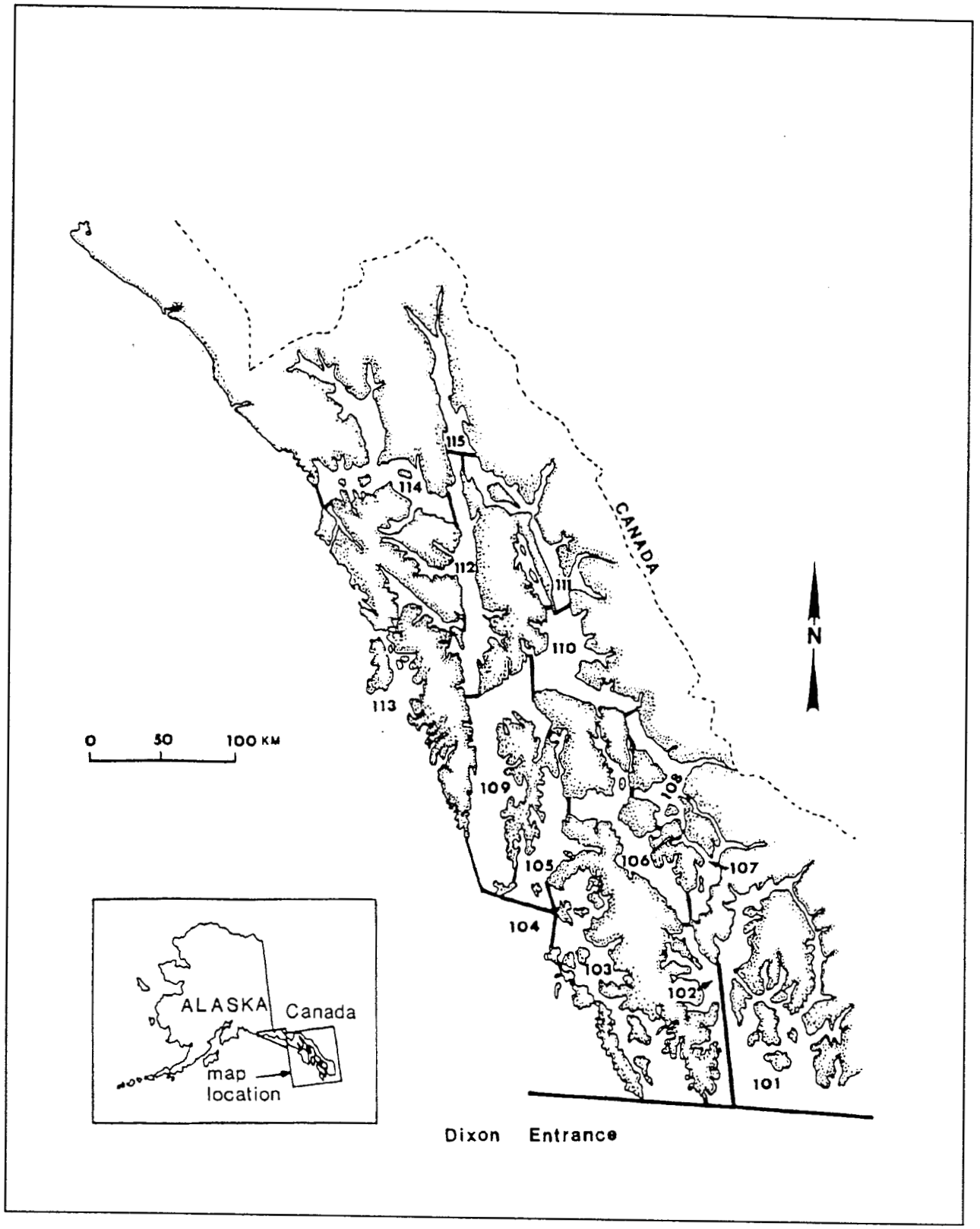

Figure 1. Location of stream district boundaries in Southeast Alaska relative to Alaska.

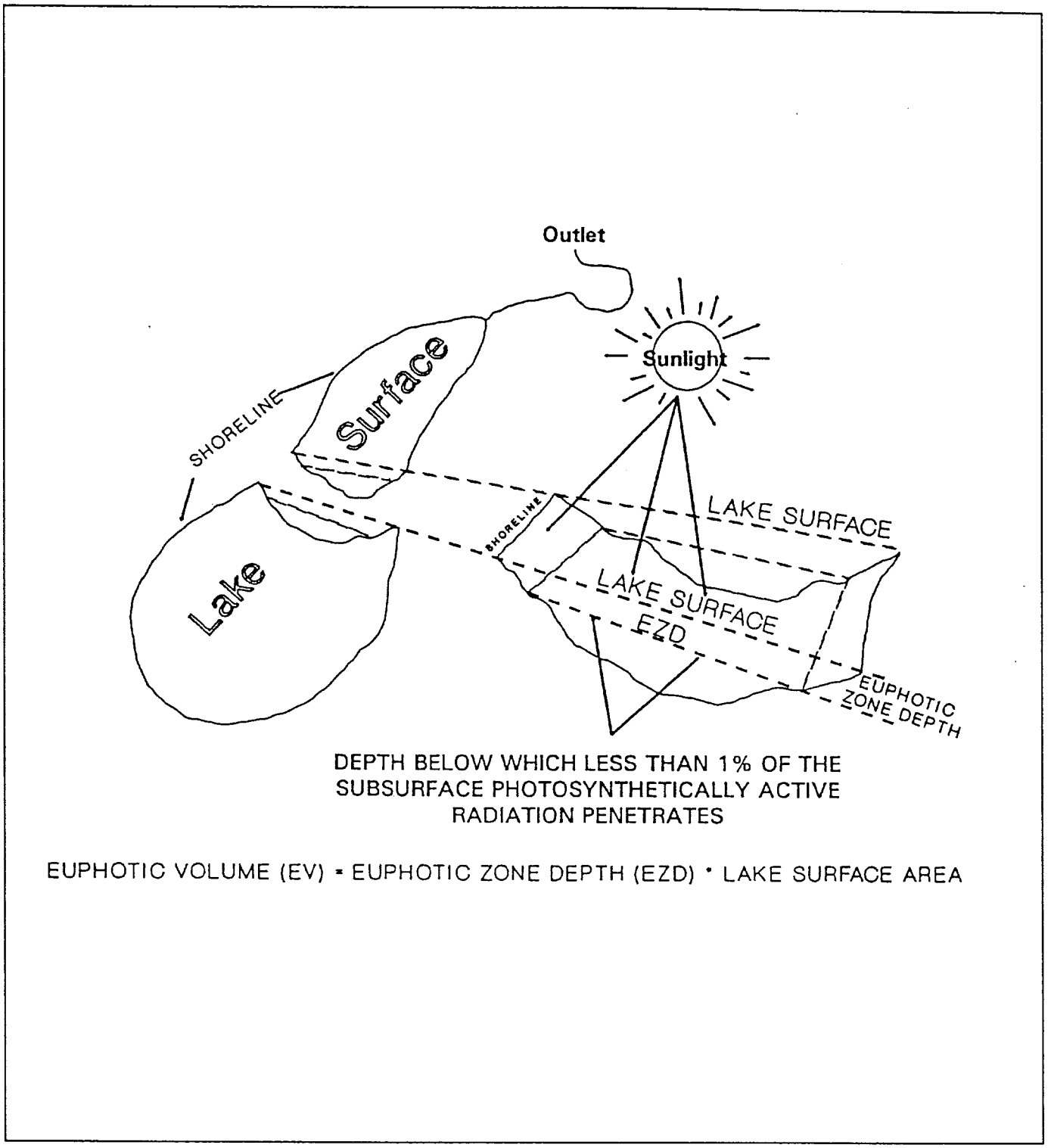

Figure 2. Euphotic volume description displayed in lake model.