Fishery Data Series No. 95-6

Fish Attraction to Artificial Structure in Chena Lakes, Alaska

by
Tim Viavant

May 1995

Alaska Department of Fish and Game

Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd
Spell out acre and ton.	

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s
Spell out year, month, and week.	

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

FISHERY DATA SERIES NO. 95-6

FISH ATTRACTION TO ARTIFICIAL STRUCTURE IN CHENA LAKES, ALASKA

by

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ABSTRACT

Three replicates each of four different types of fish attraction structures and controls (15 sites total) were placed in 4.5 m of water in Chena Lake, a man-made, interior Alaska lake stocked with rainbow trout *Oncorhynchus mykiss*, coho salmon *Oncorhynchus kisutch*, Arctic char *Salvelinus alpinus*, Arctic grayling *Thymallus arcticus*, and chinook salmon *Oncorhynchus tshawytscha*. Artificial structures were placed into the lake in early June to allow for colonization by algae and macroinvertebrates and for fish acclimation. Counts of fish in a defined zone around the artificial structures and controls were made three times for each site by two divers stationed at defined points 2.5 m away from opposite corners of the artificial structures during early August. No fish were observed near any of the artificial structures or control sites during any of the counts. Fish were occasionally observed in less than 2 m of water in nearshore areas in the vicinity of the artificial structures.

Key words: fish attraction device, underwater observation, stocked fish, rainbow trout *Oncorhynchus mykiss*, coho salmon *Oncorhynchus kisutch*, Arctic char *Salvelinus alpinus*, Arctic grayling *Thymallus arcticus*, chinook salmon *Oncorhynchus tshawytscha*.

INTRODUCTION

Artificial structure has been used extensively in fresh water to concentrate fish for sport harvest during the last 30 years (Prince et al. 1975, Stone 1985, Stone et al. 1991, Bassett *In press*). While artificial structure in fresh water has been shown (by direct observation or by test-netting) to concentrate fish (Prince and Maughan 1979, Moring et al. 1989, Walters et. al. 1991) and to increase angler success (Pierce 1967, Petit 1972, Wilber 1978, Paxton and Stevenson 1979, Wege and Anderson 1979, Aadland 1982), evaluations of fish attraction to artificial structure in fresh water have almost entirely involved warm water species such as centrarchids, percids, cyprinids, and ictalurids. This study attempts to evaluate attraction of stocked salmonids in fresh water to artificial structure.

Chena Lake is man-made, and was created in 1979 as part of the Chena River flood control project. The lake has a surface area of 105 ha and a maximum depth of 12 m (Figure 1). Because the lake was created as a result of gravel extraction, there was initially no underwater structure and substrates were comprised entirely of sand and gravel. The lake has not yet developed substantial amounts of aquatic vegetation. The lake has been stocked with rainbow trout *Oncorhynchus mykiss* and coho salmon *Oncorhynchus kisutch* since 1982, Arctic grayling *Thymallus arcticus* since 1984, chinook salmon *Oncorhynchus tshawytscha* since 1988, and Arctic char *Salvelinus alpinus* since 1989 (Table 1). In 1993 and 1994, 43,500 catchable and 83,500 fingerling fish were stocked into Chena Lake. Chena Lake supports a sport fishery that averaged 10,100 angler days and a harvest of 11,800 fish annually, all species combined, between 1984 and 1993 (Mills 1994; Table 2). This fishery is directed entirely at stocked species, since Chena Lake was treated with rotenone in 1981 to remove all native fish. Harvests have mostly been of rainbow trout and silver salmon, but 2,963 Arctic char were caught in 1993, of which all but 595 were released. For those years which both catch and harvest estimates are available, from one third to one half of all rainbow trout and coho salmon caught in Chena Lake are released and not harvested (Table 2).

Because Chena Lake lacks any areas of natural structure and substantial amounts of aquatic vegetation have not developed, there are no locations in the lake where fish are likely to

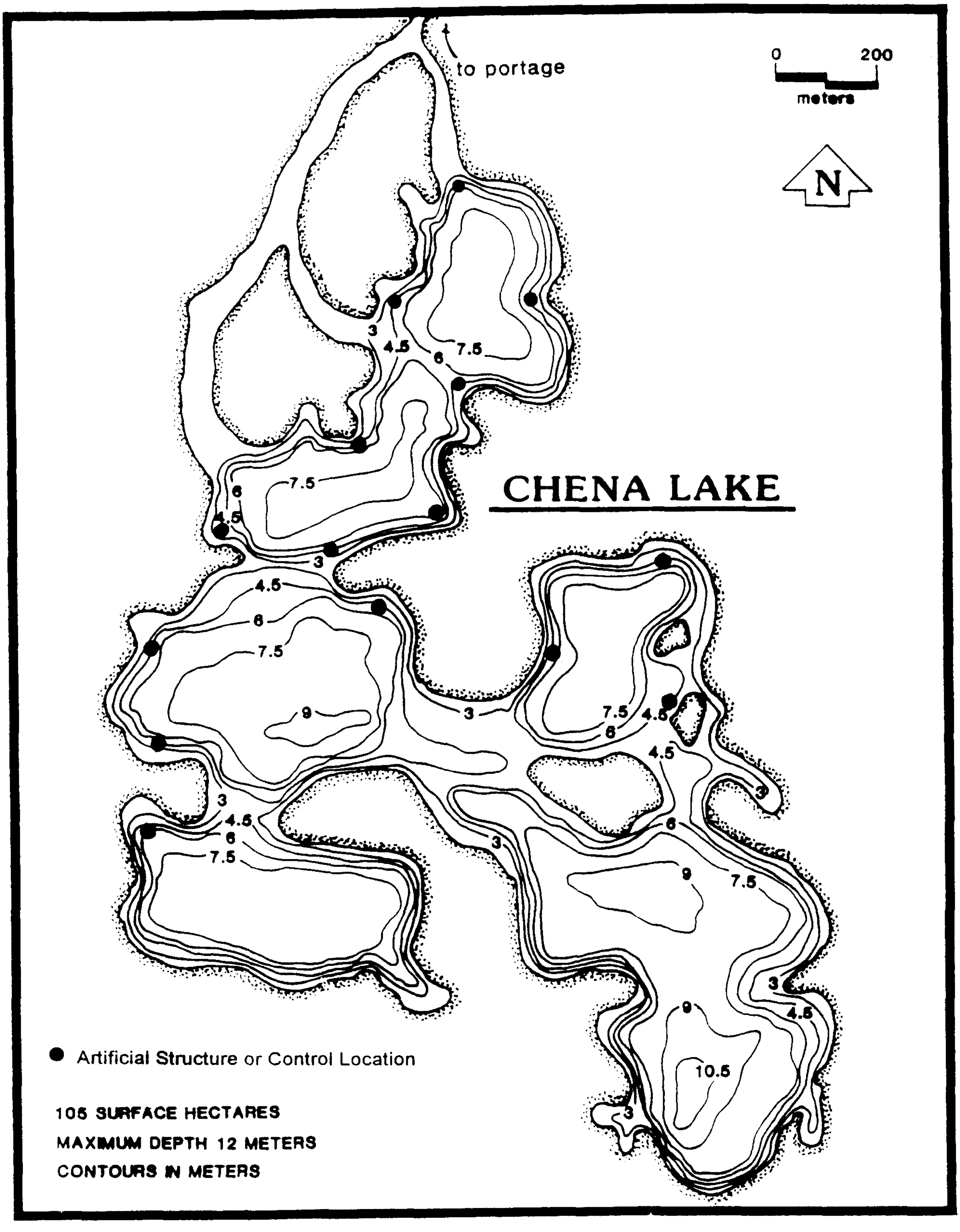

Figure 1.-Map of Chena Lake, Alaska, showing depth contours and locations of artificial structures in 1994.

Table 1.-Stocking history of Chena Lake, Alaska, 1982 to 1994.

	Rainbow Trout		Silver Salmon		Arctic Grayling		King Salmon		Arctic Char		Total	
Year	Fing. [a]	Catchable [b]	Fing.	Catchable	Fing.	Catchable	Fing.	Catchable	Fing.	Catchable	Fing.	Catchable
1982	7,500	20,000	27,500	0	0	0	0	0	0	0	35,000	20,000
1983	30,500	0	0	0	0	0	0	0	0	0	30,500	0
1984	66,000	0	30,000	0	36,800	0	0	0	0	0	132,800	0
1985	0	15,000	30,000	0	0	0	0	0	0	0	30,000	15,000
1986	0	29,000	30,000	0	400	0	0	0	0	0	30,400	29,000
1987	0	19,000	30,000	0	0	0	0	0	0	0	30,000	19,000
1988	0	30,000	15,000	0	0	0	33,000	0	0	0	38,000	30,000
1989	0	30,500	15,000	0	0	0	0		2,500	0	17,500	30,500
1990	0	31,000	0	0	0	0	0	0	0	0	31,000	0
1991	0	27,000	16,300	0	13,000	0	0	0	18,000	0	217,300	27,000
1992	0	20,000	10,500	0	15,000	0	0	0	10,000	0	35,500	20,000
1993	0	16,000	30,000	0	0	0	0	5,000	6,000	0	36,000	21,000
1994	0	16,600	15,000	0	24,000	0	0	6,600	0	10,000	33,200	39,000

[a] Fing. = Fingerlings, generally 6 grams, 75 mm in size at stocking.

[b] Catchables, in general, average 87 grams, 195 mm in size at stocking.

Table 2.-Angler effort, harvest, and catch of stocked species at Chena Lake, Alaska, 1984 to 1993.

	Effort		Rainbow Trout			Silver Salmon			Arctic Grayling		
Year	Anglers	Angler Days	Catch	Harvest	% Released	Catch	Harvest	% Released	Catch	Harvest	% Released
1984	3,101	11,044	n/a	12,032	n/a	n/a	5,036	n/a	n/a	0	n/a
1985	3,627	11,288	n/a	9,660	n/a	n/a	9,485	n/a	n/a	0	n/a
1986	2,935	8,853	n/a	7,001	n/a	n/a	1,778	n/a	n/a	0	n/a
1987	4,888	9,472	n/a	5,220	n/a	n/a	1,398	n/a	n/a	0	n/a
1988	3,311	9,404	n/a	9,877	n/a	n/a	2,401	n/a	n/a	0	n/a
1989	4,764	16,180	n/a	11,968	n/a	n/a	2,468	n/a	n/a	0	n/a
1990	5,115	12,875	23,075	8,558	63	6,718	2,313	66	0	0	n/a
1991	3,732	9,444	22,055	12,196	45	4,637	3,058	34	0	0	n/a
1992	3,378	6,007	9,618	3,602	63	5,852	1,752	70	729	8	99
1993	3,386	6,668	14,310	5,628	61	2,560	1,219	52	1,281	187	85

-continued-

Table 2.-Page 2 of 2.

Year	Effort		King Salmon			Arctic Char		
	Anglers	Angler Days	Catch	Harvest	% Released	Catch	Harvest	% Released
1984	3,101	11,044	n/a	0	n/a	n/a	0	n/a
1985	3,627	11,288	n/a	0	n/a	n/a	0	n/a
1986	2,935	8,853	n/a	0	n/a	n/a	0	n/a
1987	4,888	9,472	n/a	0	n/a	n/a	0	n/a
1988	3,311	9,404	n/a	0	n/a	n/a	0	n/a
1989	4,764	16,180	n/a	0	n/a	n/a	0	n/a
1990	5,115	12,875	0	0	n/a	0	0	n/a
1991	3,732	9,444	0	0	n/a	0	0	n/a
1992	3,378	6,007	0	0	n/a	1,245	475	62
1993	3,386	6,668	0	0	n/a	2,963	595	80

concentrate. As a result, no areas exist where angling success is likely to be higher than any other area of the lake. Because Chena Lake is stocked annually and contains no wild stock populations, there are no management concerns over stock depletion. The Chena Lake fishery is managed to maximize angler catch rates (benefit) from a given stocking density (cost). If fish could be attracted to or concentrated around certain areas, it is possible that catch rates could be increased for a given stocking density, or maintained at current levels given a lowered stocking density. Fish attraction devices could allow for a reduction in stocking density, allowing limited hatchery resources to be used at other locations.

The objectives of this experiment were to:

1. test the hypothesis that fish were not significantly attracted to artificial reefs such that a difference of 35% in the number of fish counted could be detected with probabilities of Type I and Type II errors being 0.10 and 0.20; and,
2. test the hypothesis that artificial reefs that significantly attracted fish attracted fish equally such that a difference of 35% in the number of fish counted could be detected with probabilities of Type I and Type II errors being 0.10 and 0.20.

METHODS AND MATERIALS

Three replicates of four different types of artificial structure were constructed, each structure 2 m cubed. Three artificial structures each were made of: (1) plastic milk crates banded together to form a hollow cube; (2) spruce lumber (2.54 cm x 10.16 cm) oriented vertically on 0.3 m centers in each horizontal direction; (3) 2.54 cm PVC pipe oriented vertically on 0.3 m centers in each direction with 25 cm long horizontal members on 0.3 m centers; and, (4) birch and alder log frames filled with smaller brush oriented randomly and weighted with concrete blocks (Figure 2). Artificial structures made of lumber stakes, bundled brush, and plastic pipe have been shown to attract warm water fish species in previous studies (Lynch and Johnson 1988, Petit 1972 [lumber stakes], Graham 1992, Moring et al. 1989 [bundled brush], Walters et al. 1991 [plastic pipe]). Three replicate control areas were marked with 2 m square PVC pipe frames placed flat on the lake bottom. No attempt was made to color structures so as to make them blend in with the natural color of the lake bottom. Pipe structures and stake beds did not blend well with the lake bottom. Milk crate and brush structures did tend to more closely match the lake bottom color.

All structures were placed at random locations into Chena Lake in approximately 6.5 m of water eight weeks prior to evaluation. Locations were chosen such that no structure was within 175 m of any other structure (Figure 1). Initial attempts at evaluation revealed that underwater visibility was too poor (less than 0.5 m in some locations) at this depth. Because of poor visibility, the structures were moved into water approximately 4.5 m deep adjacent to the original randomly selected locations. Under-water visibility at this depth was at least 4 to 6 m during the evaluation period. Artificial structure locations were left unmarked because of the fear that surface marker buoys would be vandalized (removed). Initial attempts at evaluation proved that locating the structures without some kind of marker buoy was very time consuming. Therefore, structures were marked with a buoy placed approximately 1.5 m under the water surface. Artificial structures marked in this way could generally be located quickly.

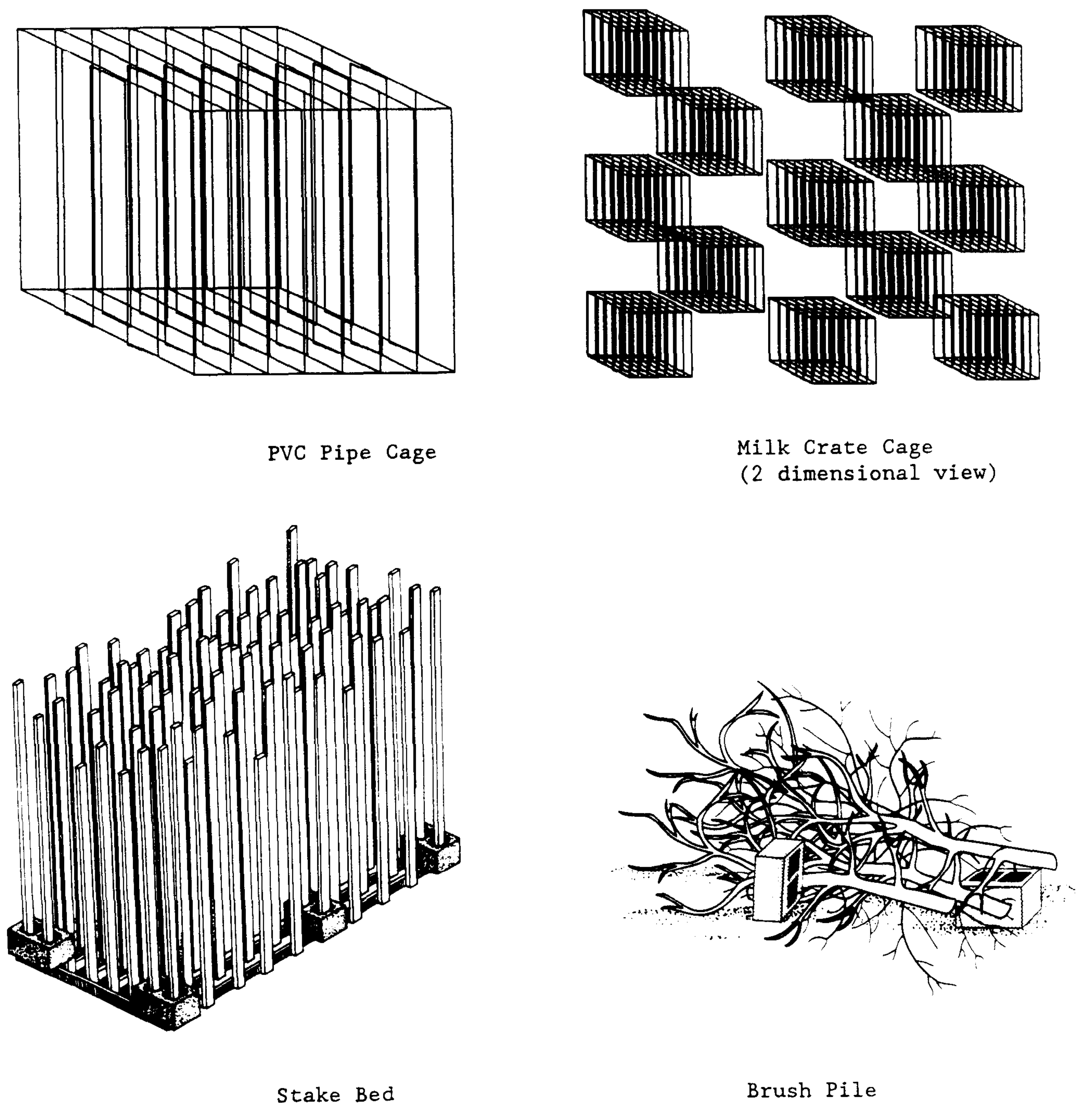

Figure 2.-Diagram of the different types of fish attraction devices placed into Chena Lake, Alaska, in 1994.

Fish counts were made using a method modified from Davis and Anderson (1989) and Graham (1992). Divers were stationed at marked points 2.5 m from opposite corners of each artificial structure or control site (Figure 3). Five counts were made (one count each minute) over 5 minutes beginning 10 minutes after both divers were at rest near marked stations to allow fish to acclimate to the observers presence. Fish were counted if they were within a defined area around the structures bounded by a 90 degree wedge, the sides of which paralleled the sides of the artificial structures and the apex of which was located at the marked station where the observer was located (Figure 3). The one-minute counts from each diver were summed for that minute having the single highest count from either diver. Counts were made in random order among the 15 sites three different times and started over with a new random order for each of the three counts. Divers submerged adjacent to the tender approximately 30 to 40 m away from the structures and approached from under water to minimize the possibility of disturbing fish in the vicinity of the structures.

RESULTS AND DISCUSSION

No fish were observed around any of the artificial structures or control areas during the entire observation period. Because no fish were observed at either the structures or control sites, the null hypothesis of objective one is not rejected as the data show that fish were not significantly attracted to artificial structure in Chena Lake. Because the null hypothesis of objective one was not rejected, the data provide no basis for evaluating the null hypothesis of objective two.

Small numbers of fish were observed in nearshore areas less than 2 m deep in the vicinity of the artificial structures, sometimes from under water by divers swimming towards shore, and more often from above water by the tender operator. While counts of fish sighted in the vicinity of the artificial structures were not made systematically during every observation period, generally only two to five fish were observed.

Daily average water temperatures (in ° C) at the beginning of the evaluation period were 11.6 at 5.5 m, 14.0 at 4.8 m, 16.1 at 4.2 m, 18.7 at 3.6 m, 20.6 at 3.0 m, 21.8 at 2.4 m, and 22.1 at 1.8 m. These temperatures increased by approximately 1 °C during the seven day evaluation period. Water temperatures at the structures ranged from approximately 15 °C near the bottom of the structures to approximately 22 °C near the top of the structures (Figure 4).

While this experiment was not designed to determine what factors cause salmonid fishes to be attracted or not attracted to artificial fresh water structure, the following possibilities may explain these results. It is possible that salmonid behavior in lentic waters does not include attraction to structure. Salmonid species have been shown to be attracted to cover/structure in lotic waters (DeVore and White 1978, Fausch 1993), but such attraction may be related to drift feeding (Everest and Chapman 1972) or maintaining position in current (Schuler et al. 1994, Fausch and White 1981), factors which do not apply in lentic waters.

It is also possible that hatchery reared salmonids behave differently with respect to structure than wild salmonids, and that results observed in this study may not apply to lakes containing

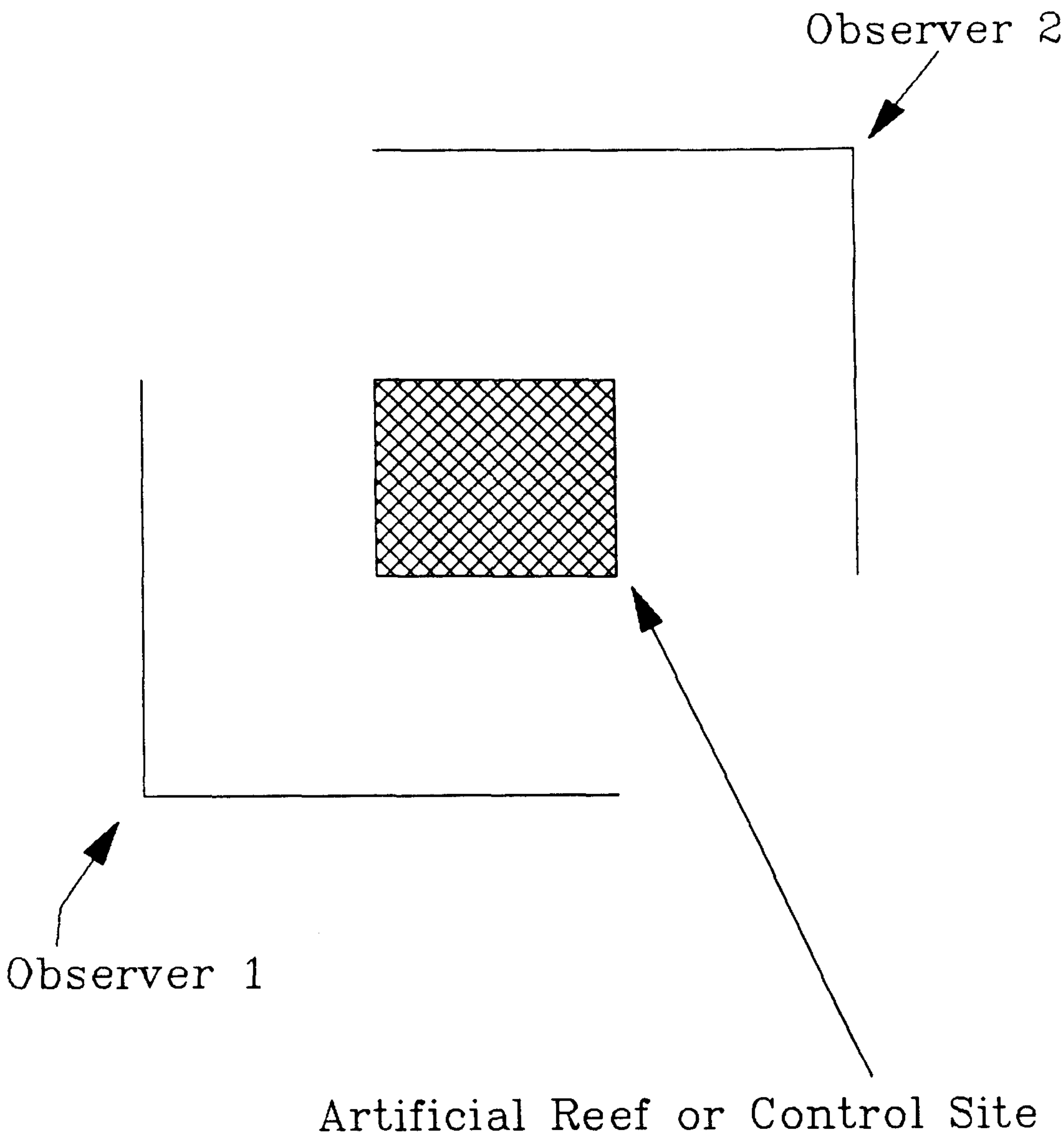

Figure 3.-Diagram showing spatial limits of observation area around each reef or control site.

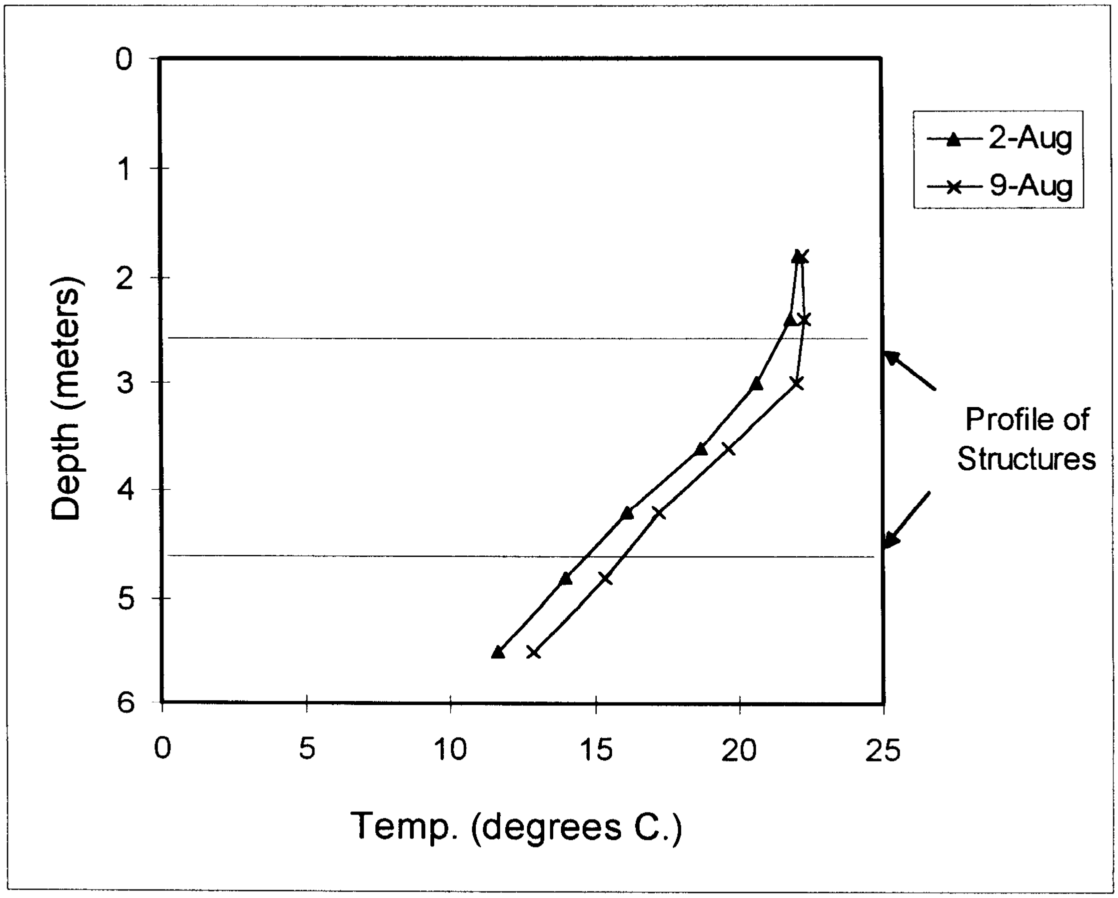

Figure 4.-Daily average water temperatures and depth profile of artificial structures in Chena Lake, Alaska, at the start and finish of the evaluation period.

naturally reproducing salmonid stocks. Stocked salmonids have been shown to behave differently with respect to cover than wild salmonids. Vincent (1960) found that hatchery reared brook trout *Salvelinus fontinalis* avoided cover, failed to exhibit a fright response to water disturbance, and maintained positions close to the water surface while wild brook trout sought out cover, fled in response to surface disturbance, and maintained positions near the bottom of the water column. Hatchery reared rainbow trout have been found to select areas having no instream or overhead cover when introduced into streams (Miller 1954, Hillman and Chapman 1989). Wiley et al. (1993) suggest that hatchery reared trout are conditioned to avoid cover as predators are excluded in the hatchery environment and hatchery fish are conditioned to overhead feeding stimuli. It is also possible that stocked salmonids do not utilize habitat below a certain depth. Threinen (1958) noted that rainbow trout introduced into a lake at a depth of 6 m immediately swam to the surface and refused to swim deeper than 4.5 m, even when epilimnetic water was at a temperature above their thermal tolerance. Many of these fish died (presumably of thermal shock) rather than seeking cooler water below 4.5 m.

The lack of fish attraction to artificial structure in Chena Lake could be due to the depth at which artificial structures were placed. Prince et al. (1985) found a species-dependent (Basses, Bluegills and Sunfish) attraction to artificial structure in deep versus shallow water and that all fish presence on artificial structure was correlated with water temperature. Fish were only present on artificial reefs when surface water temperatures were greater than 10 ° C. Lynch and Johnson (1988) found that pop-net catches of white crappie *Pomoxis annularis* were significantly higher from artificial structure in 4 m deep water than from 2 m deep water, and that the influence of depth on attraction to artificial structure seemed to be related to the depth of the metalimnion with fish being more abundant on deeper artificial structures as the depth of the metalimnion increased over the summer. It is notable that while the findings of Prince et al. (1985) indicate that water temperature must be above a critical level for fish to be attracted to artificial structure, Lynch and Johnson (1988) seem to show that water temperature must be below a certain level for fish to be attracted to artificial structure.

The artificial structures present in Chena Lake were at the depth of the thermocline, with water temperatures above 20 °C around the top of the structures and 14 °C around the bottom of the structures (Figure 4). This would tend to indicate that temperature alone does not explain the lack of structure use observed as temperature differences between water at the top of the structures and water in shallow, nearshore areas (where some fish were observed) were small.

Stocked salmonids (Arctic char) have been observed congregating underneath floating docks that were installed into Harding Lake during a previous ADF&G study (Viavant 1992). These floating docks were installed to attract fish and were equipped with automated feeding stations. The docks were located over water 12 m deep. Fish were probably attracted to these artificial structures because of the feeding stations as all fish observed and caught adjacent to the docks were recently stocked. However, fish were observed maintaining positions around the docks even when feeding was not occurring. Fish may have been attracted to these docks because of overhead cover provided by the docks. Artificial structures installed in Chena Lake did not provide substantial overhead cover because materials were generally oriented vertically. The only fish caught from under the Harding Lake floating docks were Arctic char, and these fish were often caught near the bottom of the lake. Underwater visibility at Harding Lake appeared to be substantially better at depths over 10 m than in Chena Lake, a factor which could affect fish attraction to cover or artificial structure.

Underwater visibility at Chena Lake was highly variable, both with depth and between different areas. Visibility was very poor below 5 m in some lake areas. This was due to very fine suspended material in the water column. This layer of suspended material reduced visibility and light penetration in the north-east basin of the lake, and was much less dense in other lake areas. This suspended layer of fines could be due to groundwater upwelling in the area of the lake were it was most prevalent. While this layer of suspended fines prevented evaluation at the depths that artificial structures were initially placed, visibility and light penetration were excellent once the structures had been moved to shallower water and low visability should not have had an effect on results.

Stocked salmonids in Chena Lake may select water that is 2 m deep or less based on the spatial distribution of food resources. However, the artificial structures placed in Chena Lake were well colonized by algae, snails, and other macroinvertebrates by the time evaluation took place. It is also possible that fish in Chena Lake were avoiding low levels of dissolved oxygen at the depths that the structures were placed. While dissolved oxygen levels were not measured in Chena Lake during the evaluation period, it seems unlikely that low dissolved oxygen levels would occur at depths where structures were placed as algal growth was abundant on the structures.

Chena Lake, having little natural structure or cover, and containing only stocked salmonids, may not be ideally suited to determining salmonid response to artificial structure. Placing artificial structure in a lake containing wild stock salmonids and having some existing areas of natural structure or cover might lead to differing results. Chena Lake does have a very well developed shoreline, and the littoral zone comprises a high percentage of total lake area. This results in abundant shallow water habitat. In a lake having less littoral zone (in relation to total surface area), shallow water habitat might be limiting, and fish may be more likely to utilize habitat created by artificial structure. It may also be of interest to evaluate fish attraction to artificial structure in a lake containing non-salmonid species such as northern pike and least cisco, although such a study would not necessarily provide information about salmonid attraction to artificial structure.

The results of this study leave many questions unanswered. Future research on salmonid attraction to artificial structure in fresh water should investigate the role of depth, water temperature, and dissolved oxygen levels. The response of fish to overhead cover versus structural complexity as well as potential differences in the behavior of stocked verses wild fish towards cover/structure should also be examined.

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