

## Relative Efficiency of the Midwater and Kodiak Trawl at Capturing Juvenile Chinook Salmon in the Sacramento River

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### INTRODUCTION

In order to increase capture of the larger chinook salmon that are believed to have evaded the midwater trawl net used in the past, the Kodiak, or pair trawl, was added to the Interagency Ecological Program (IEP) sampling regime near the city of Sacramento. Using one boat on each side of the net, the Kodiak trawl sends fish into the center of the net in a herding fashion (Noel, 1980). The additional power of an extra boat enables a larger net to be pulled creating an increased fishing area. In situations where fish are sparsely distributed (i.e., winter, late-fall, and yearling spring run), it is important to use a net with an enlarged mouth opening to improve the chance of capture (Sainsbury, 1996; McNeely, 1964). Salmon may not recognize they are trapped until they are unable to escape (McNeely, 1964). The small mesh size of the Kodiak trawl could increase salmon retainment as opposed to the midwater trawl net, which has considerably larger mesh towards the mouth. However, the effects of back pressure on the two nets are not known. The two-boat effect on herding might be significant and partially responsible for an increase in efficiency as discussed by Noel (1980).

This pilot study was done by the U.S. Fish and Wildlife Service (USFWS) to identify the relative efficiency of the Kodiak and midwater trawl nets used at Sacramento. The study was conducted to answer four questions:

- Does the Kodiak trawl catch larger salmon?
- Does the Kodiak trawl catch more salmon?
- Do the results of the Kodiak trawl show a higher density of salmon than the midwater trawl?

- Is the Kodiak trawl worth the additional effort?

The Kodiak trawl offers a much larger mouth opening (maximum of 1.8 X 7.6 m) than the midwater trawl net (maximum of 1.8 X 4.5 m). In addition, it has a leading footrope (Figure 1) to offset the downward flight of fish. Past studies indicate an increase in catch of pelagic species when changing from a midwater to a Kodiak trawl (Garner, 1978). Thompson (1978) found two boat trawls to produce four to ten times as much fish as single vessel trawls off the Ivory Coast in West Africa.

Historically, the IEP used catch per twenty minute tow on the Sacramento River near the city of Sacramento, and in Suisun Bay adjacent to Pittsburg, as a means of comparing relative abundance of chinook salmon. In recent years, trawling effort was reported more precisely by using the volume of water sampled rather than tow duration.

Theoretically, density could be compared between and within gears and used to analyze trends in abundance and distribution. Because the midwater and Kodiak trawl nets are designed differently, relative efficiencies needed to be analyzed to validate these comparisons.

### METHODS

Between April 1, 1996, and April 4, 1996, ten twenty-minute comparison tows were attempted daily on the Sacramento River at river mile 55 with the Kodiak and midwater trawl. Tows were conducted simultaneously, adjacent to each other in the main channel of the Sacramento River. Boats alternated locations in the river to avoid a position bias. All fish captured were identified and enumerated. A maximum of 50 of each race of chinook and 30 of all other species of fish were measured to the nearest millimeter fork length. Water temperature, time, and flow meter readings also were recorded after each tow. Water turbidity was recorded to the nearest centimeter with a secchi disk at the beginning of each tow.

The midwater trawl net (Figure 1) was a variable mesh net with a fully extended mouth size of 1.83 x 4.57 meters (6 x 15 feet) tapering to a cod end of 0.32 cm (1/8 inch) mesh (USFWS, 1987). One pair of metal bottom doors sink and spread the net at the lead line and one pair of aluminum top doors with floats spread the top of the net at the surface.

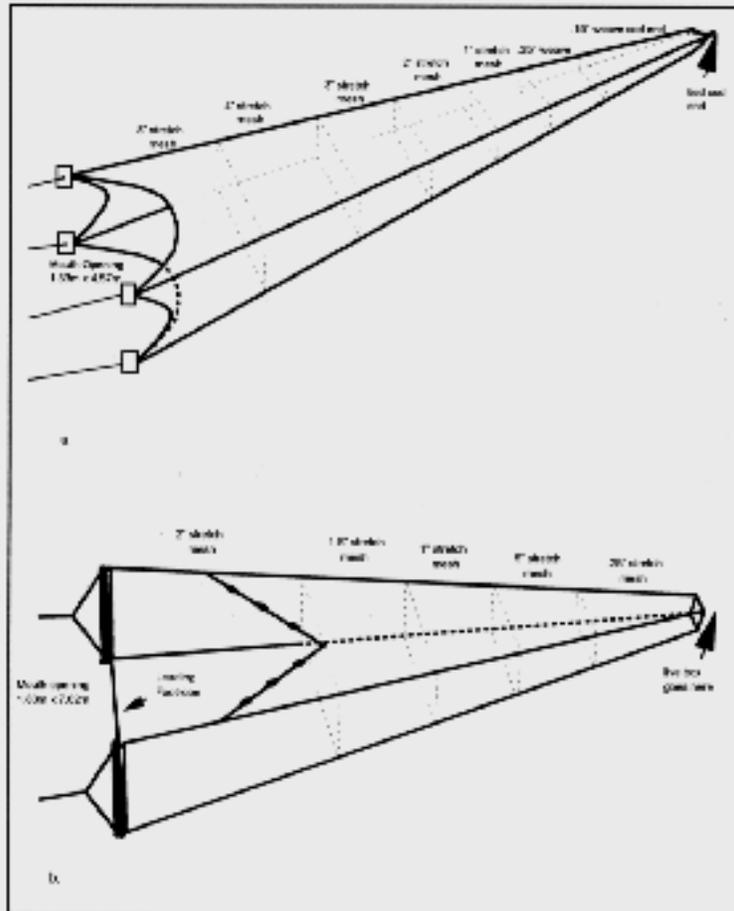


Figure 1. Schematic drawing of midwater (a) and Kodiak trawl (b) nets used in study at Sacramento.

The Kodiak trawl net (Figure 1) was constructed of variable mesh with a fully expanded mouth opening of 1.83 x 7.62 meters (6 x 25 feet). A weighted footrope and headrope with floats allow the net to fish the top 1.8 meters of the water column. The Kodiak trawl was fished with aluminum live box as a cod end to minimize chinook salmon mortality. Two boats pulled the Kodiak net through the water, one towing each wing. A 1.8-meter bar was attached to the front of each wing keeping the depth of the lead line constant. At the end of each tow, one of the boats retrieved the live box and removed the fish. Though

the depth the net fished was relatively constant due to the spreader bars, the width of the mouth opening was affected by the boats pulling it and varied within and between tows.

Though the midwater trawl is called such due to its design, it fishes at the top of the water column. Actual fishing dimensions of the net vary and have been described in past reports (USFWS, 1993). The mean effective fishing mouth size of the net mouth was found to be 5.08 m<sup>2</sup> based on these studies. The estimated fishing net mouth size of the Kodiak trawl was 12.54 m<sup>2</sup>. The catch per cubic meter and mean amount of water sampled reported in this paper were based on these preliminary fishing mouth dimension studies.

Meters of water sampled were measured with a General Oceanics mechanical flow meter (model 2030). Linear meters were calculated by multiplying meter rotations with the Standard Speed Rotor Constant (26,873) and dividing the result by a conversion factor (999999). Linear meters traveled per tow were multiplied by the mouth opening of the net to calculate the volume of water sampled. Dividing total catch by volume yielded a density measurement to be used for relative abundance.

Total chinook catch, density, and mean fork length per tow as well as linear and cubic meters fished were tested for normality using SYSTAT descriptive statistics function (SYSTAT for Windows version 7). Catch per tow and mean water sampled distributions were not normal and tested with the Mann-Whitney U test. Mean fork length and salmon density were tested with a t-test.

## RESULTS

The mean number of chinook captured per tow was 55.7 (standard error = 4.0) in the Kodiak trawl and 21.3 (standard error = 2.3) in the midwater trawl (Table 1, Figure 2). Catch of all salmon was found to be significantly higher in the Kodiak trawl ( $p = 0.000$ ).

The mean fork length of salmon captured was 70.8 (standard error = 0.35) in the Kodiak trawl and 68.7 (standard error = 0.22) in the midwater trawl (Figure 3). Mean fork length was found to be significantly higher by 2.0 mm in the Kodiak trawl ( $p = 0.007$ ).

The mean volume of water sampled per tow with the Kodiak trawl was 12,314 (standard error = 238.2  $m^3$ ), while the mean for the midwater trawl was 5,438 (standard error = 63.9  $m^3$ ), significantly less than the Kodiak trawl (Table 1).

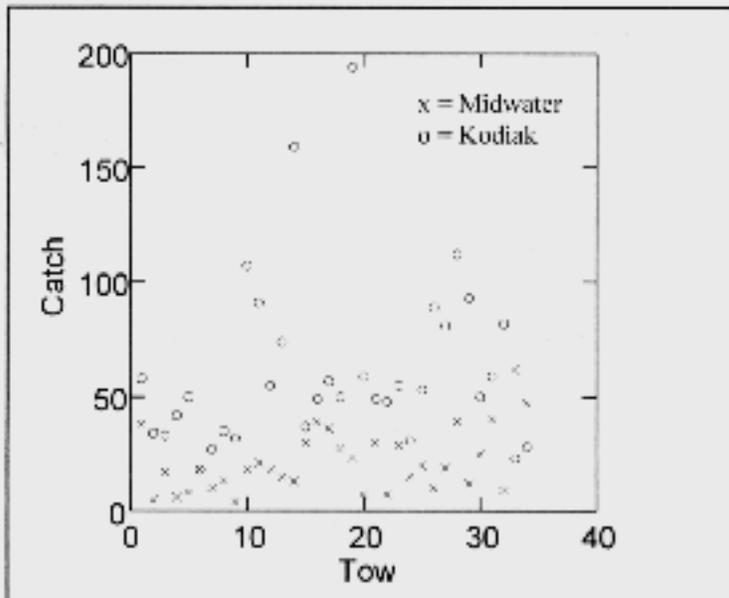
The density of chinook salmon was 0.00469 (standard error = 0.00036  $m^{-3}$ ) in the Kodiak trawl and 0.00387 (standard error = 0.00039  $m^{-3}$ ) in the midwater trawl. A probability of 0.13 suggested there is no difference in efficiency.

Water clarity, as defined by secchi disk was comparable between the two gears and had an overall range of 0.30 to 0.56 meters in the Kodiak trawl and 0.27 to 0.49 in the midwater trawl.

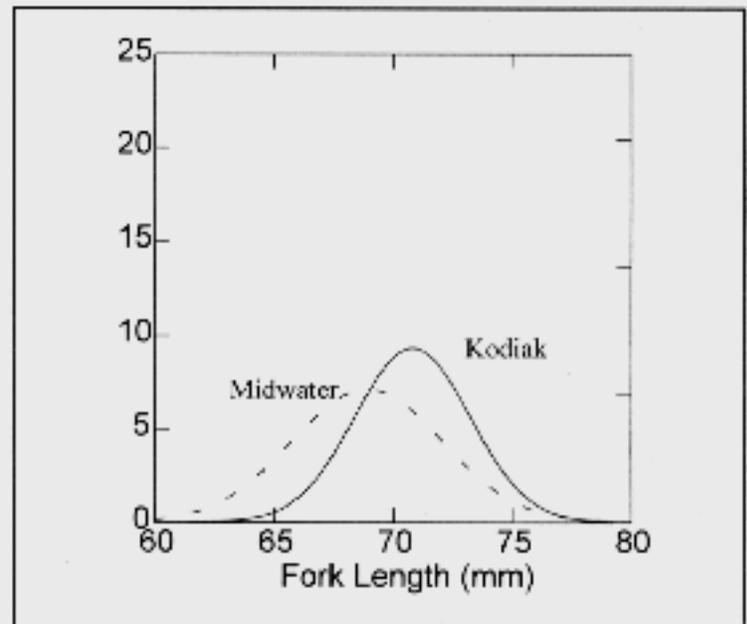
**Table 1. Mean and range per tow of water sampled ( $m^3$ ), chinook catch, fork length (mm), and chinook density in the Kodiak and midwater trawl as well as the probability level and sample size.**

	Kodiak		Midwater					
	Mean	Range	Mean	Range	n	Test	p	Significant?
Salmon Catch	55.7	18 - 103	21.3	4 - 62	34	Mann-Whitney	0.000	Yes
Fork Length	70.8	38 - 112	68.8	32 - 100	34	T-test	0.000	Yes
Water Sampled ( $m^3$ )	12,314	10,557 - 19,190	5,438	4,828 - 6,311	726	Mann-Whitney	0.000	Yes
Salmon Density ( $m^{-3}$ )	0.0047	0.0014 - 0.0088	0.0039	0.0008 - 0.0098	33*	T-test	0.13	No

\* One tow deleted from cubic water sampled and density calculations because of a faulty flow meter reading.



**Figure 2. Plot of salmon catch per tow in the Kodiak/midwater trawl experiment conducted between April 1 and April 4, 1998, at Sacramento.**



**Figure 3. Density plot of mean fork length per tow in the Kodiak/midwater trawl comparison experiment between April 1 and April 4, 1998, at Sacramento.**

## DISCUSSION

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The results of this study indicate that the Kodiak trawl captured larger fish than the midwater trawl during the spring of 1996 at Sacramento. Though the Kodiak trawl selected chinook that were on average two millimeters larger, the fish in the Sacramento River during the spring were mostly composed of fall run hatchery smolts released from Coleman National Fish Hatchery which usually have a narrow size frequency. The results may have been different if a larger variation in size was present during our pilot study. The different design of the Kodiak net may increase the selection ability of larger sized salmon as shown by the results of fork length distributions.

To thoroughly test the size selectivity and relative efficiency of the two gears on larger chinook, comparison trawls should be done in the fall months during winter and late-fall run, as well as spring run yearling juvenile migration seasons. The fish composition during this time of the year would be composed of a mixture of yearling and fry sized salmon and present the experiment with a larger and potentially more variable fork length distribution to test.

The two trawls cover comparable linear distance during a tow, however, the effective fishing mouth opening of the Kodiak trawl is larger and is built differently than the midwater trawl net. As a result, the Kodiak trawl captured more salmon per tow than the midwater trawl, but density values were not found to be significantly different. The larger catches in the Kodiak trawl also enabled more of the larger, less abundant fish to be captured.

Because densities appeared similar in the Kodiak and midwater trawls, it will be feasible to use the two gears interchangeably for abundance and timing information for chinook density during the spring.

The Kodiak trawl should continue to be utilized to maximize effort at catching larger chinook salmon in the Sacramento River. Consideration should be given to using a larger Kodiak net if logistically pos-

sible. Further analysis should be done during the fall and winter seasons to take advantage of the fry, smolt, and yearling sized salmon in the system.

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## Simulated Effects of Delta Outflow on the Bay –1998 Compared to Other Years

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## INTRODUCTION

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Water year 1998 was characterized by above average precipitation from January through June throughout the 400,000 km<sup>2</sup> San Francisco Bay-Delta watershed. Cool temperatures delayed the peak snowmelt until early July, keeping streamflows above average well into the summer (DWR 1998a). This was similar to another strong El Niño in recent history, WY1983. These years stand in sharp contrast