

USE OF DUAL FREQUENCY IDENTIFICATION SONAR TO MONITOR STEELHEAD ESCAPEMENT IN THE SMITH RIVER, CALIFORNIA, 2012-2013



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USE OF DUAL FREQUENCY IDENTIFICATION SONAR (DIDSON) TO MONITOR STEELHEAD ESCAPEMENT IN THE SMITH RIVER, CALIFORNIA

ABSTRACT

Long Range Dual Frequency Identification Sonar (DIDSON) was used to quantify adult fish passage 24 hours per day during the winter steelhead run-time in the Smith River, Del Norte County, California. Two long range DIDSON units operated continuously at river mile 6 for 108 consecutive days from 14 Dec 2012 to 31 Mar 2013. The number of adult fish counted passing upstream was 9,562 fish and 784 adult fish were counted passing downstream. A 20 minute per hour sampling rate was applied to the entire data set and the percent error for the season was less than 2 percent. Percent error highest during March (24 percent) lowest during February (0.1 percent), indicating that results of studies with reduced sampling rates may be affected during kelt migrations. A high resolution lens fitted to the left bank DIDSON improved the image quality of fish at greater ranges and reduced positive bias in fish length measurements. Fish lengths averaged 74 cm during the study. Data were compared to weir counts at Rowdy Creek, a Smith River tributary located 2 miles downstream from the DIDSON station, and spikes of upstream fish passage at the DIDSON station coincided with peak steelhead counts at Rowdy Creek. This study provides the third consecutive year of time series DIDSON data for the Smith River during the winter steelhead run for helping to assess steelhead status and trends.

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INTRODUCTION

Monitoring the abundance of Pacific salmon returning to rivers to spawn, or escapement, is critical for evaluating the status and trends of populations, managing fisheries and identifying conservation needs. The raw data upon which salmon and steelhead escapement estimates are developed for northern California rivers are based on spawning ground surveys, dam counts, and angler-use information (Good et al. 2005, Ford et al. 2010). While this information is useful for resource managers it does not provide a complete measure of anadromous salmonid abundance or escapement for individual rivers and streams, and in most cases the data represents only a fraction of spawning grounds in a basin or region.

Anadromous fish escapement information for the West Coast is often limited by the financial, physical and technological constraints involved with collecting continuous anadromous fish information in dynamic, relatively large and often turbid stream conditions inherent of coastal anadromous streams. New adult abundance monitoring approaches and techniques are needed to help evaluate the status and trends of all anadromous fish populations. In this study, a fixed location, multiple DIDSON fish counting station was operated to collect basin-wide steelhead abundance information in the Smith River, California's fourth largest coastal river (Figure 1).

DIDSON is a multi-beam, high-definition imaging sonar that can detect and identify fish in dark and turbid aquatic conditions to a range of at least 40 meters. The technology produces images of fish in real time that can be recorded like video, analyzed with software and the data can be archived. DIDSON can be deployed in large rivers or small streams and does not require handling fish, modifications to the environment or State and Federal permits to operate. DIDSON are the size of a car battery and can be deployed from a submerged, stationary position near the water's edge to ensound a subsection or an entire cross-section of a submerged channel. Fish can be imaged, counted and measured as they pass through the sonar beams. Unbiased fish counts and reasonably accurate length measurements can be manually derived or semi-automated with software.

Fixed location DIDSON fish counting stations are becoming more widespread to estimate basin-wide salmon and steelhead escapement (Galbreath and Barber 2005; Holmes et al. 2006; Burwen et al. 2007; Johnson et al. 2006; Maxwell and Gove 2007; Metheny 2012; Mueller et al. 2008, Pipal et al. 2010, Pipal et al. 2012). The use of DIDSON is proposed by the California Coastal Salmonid Monitoring Plan (CMP) (Adams et al. 2011) for Southern California steelhead populations, and DIDSON is currently used in Santa Cruz County (Pipal et al. 2011, Pipal et al. 2012), Santa Barbara and Ventura Counties (Steve Howard pers. comm., Dana McCanne pers. comm). In the CMP Northern Region, regional sample-based spawner survey methods described in Gallagher (2005) are included in the CMP for targeting adult coho salmon abundance (Adams et al. 2011).

Similar studies are being conducted in Northern Region, including in Redwood Creek (Metheny 2012) and the Mad River (CDFW), for investigating the usefulness of DIDSON in estimating total anadromous fish escapement to moderately large streams. The advantages of using DIDSON to monitor the status and trends of anadromous fish in the Northern Region of California include the ability to: operate in rivers too wide or powerful for barrier weirs or too turbid for visual observations; collect protected species data without handling fish or affecting critical habitat; monitor anadromous fish migrations 24 hours per day; validate spawning ground surveys, and; observe behavioral patterns of anadromous fish and detect rare events (e.g. sturgeon).

This study follows the Smith River DIDSON Pilot Study that operated continuously from October to April, 2010-2012. Due to funding complications, the objectives from the original study to monitor salmon and steelhead were changed to capture the relatively discrete steelhead run-time in the Smith River. Further study objectives were to:

1. Investigate the usefulness of DIDSON fish counting stations for achieving California Coastal Salmonid Monitoring Plan Objectives.
2. Compare DIDSON count data with Rowdy Creek Fish Hatchery Weir data.
3. Collect length frequency information with a high resolution lens (“large lens”).
4. Provide a baseline for monitoring the status and trends of Smith River steelhead.

SITE DESCRIPTION

The Smith River is the fourth largest coastal river in California and has the unique status as the State’s last major free flowing river that drains directly into the Pacific Ocean. The Smith River is famous for water clarity, its world-class salmon and steelhead fishing and its ancient redwood forest groves (SRAC 2002). The watershed exists within Redwood National and State Park and National Forest boundaries, is designated a Key Watershed under the Pacific Northwest Forest Plan and has National Recreation Area and Wild and Scenic River status. The Smith River was endorsed by the North American Salmon Stronghold Partnership as a Stronghold Basin in 2007.

The Smith River originates in the Siskiyou Mountains of the Klamath Geologic Province and enters the Pacific Ocean 4 miles south of the Oregon Border in Del Norte County, California. The total watershed area is approximately 1,862 km² (720 mi²) with 236 km² in Oregon in the North Fork sub-basin. The elevation ranges from sea level to 1,958 m. The total length of stream channel is 5,000 km of which about 483 km is available for anadromous fish (McCain et al. 1995). Annual rainfall amounts range from approximately 1778 mm (70 in.) at the coast to over 3800 mm (150 in.) in the interior. The precipitous terrain and elevation drop creates a fast response time of stream flow to rainfall events. The Smith River has the largest mean annual runoff per area of any major watershed in California (Rantz, 1969) and is prone to periodic large scale flooding, particularly during rain-on-snow events. Mean monthly flow values in the Smith River, based on USGS gauging station data, range from about 8.5 cubic meters per second (cms) or 300 cubic feet per second (cfs) in August and September, to around 230 cms or 8,000 cfs in December and January.

The status of Smith River Chinook salmon, coho salmon and steelhead trout and their associated Evolutionary Significant Units (ESU’s) are included in Table 1. For a list of all anadromous fish in the Smith River and their status descriptions see Appendix A. Only coho salmon are listed under the Endangered Species Act (1973) as a Threatened Species in the Southern Oregon and Northern California Coast ESU. Otherwise fall Chinook salmon and steelhead populations in the Smith River are considered healthy and continue to support popular recreational fishing opportunities. There is no evidence of a long term decline in the fall-run Chinook population, but data are limited (Moyle 2002). In 1997 the California Department of Fish and Wildlife recognized the Smith River as being California’s most robust steelhead population but overall there was widespread concern that Klamath Mountains Province (KMP) steelhead populations were in general depressed from historic levels (CDFG 1997).

In 1960 the US Fish and Wildlife Service provided a survey report, at the request of the Department of the Interior, to establish a baseline of fish and wildlife resources in northern California (USFWS 1960, 1965) (Table 2). However, “estimates given here which are based on little or no data should be used only in

outlining the major and critical factors of the resource” (CDFW 1965). The basin-wide estimates of spawning abundance in the Smith River exclusive of catch were: King (Chinook) salmon, 15,000 fish; Silver (coho) salmon, 5,000 fish; and steelhead, 30,000 fish. Except for the Trinity River, recent estimates of steelhead run sizes are not available for any of the major runs in the KMP (CDFW 1997). Moyle (2002) described the Smith River as a relatively unaltered stream that never supported a large Chinook population. He reported annual estimates of Chinook salmon in the Smith River are generally 15,000-30,000 fish.

The Smith River DIDSON Station is located 1.8 river miles upstream from the mouth of Rowdy Creek (RM 4), a lower Smith River tributary (Figure 2). In 1970, the governor signed Senate Bill #1047, which authorized the Kiwanis Club of Crescent City to build the first privately owned fish hatchery in California. The hatchery facilities included a barrier weir fish trap that provides one of the longest set of annual anadromous abundance data for the Smith River. In general peak counts of Chinook salmon at the hatchery facility occur during November and typically cease around 15 December (Andrew Van Scoyk, pers. comm.). Coho salmon, though very few are observed at the weir, have passed through the facility in October and again in late December. Although Rowdy Creek salmon and steelhead run times overlap, peak numbers of steelhead at the hatchery are observed in mid-January. These run times are similar to the general run-timings observed in the Smith River (Table 3). The weir data provides opportunities for species run timing comparisons and additions of weir counts to basin-wide escapement counts or estimates.

MATERIALS AND METHODS

Site Selection

The Smith River DIDSON Pilot Study site was located in the lower Smith River at the Public Boat Launch facility, one river mile downstream from the Highway 101 Bridge and 6 river miles (RM) upstream from the mouth of the river (Pacific Ocean). Site selection for the Smith River DIDSON Station was based both on its location upstream from tidal influence and downstream from major spawning grounds in the mainstem Smith River and numerous tributaries. Additional considerations for appropriately siting the station included channel geometry, availability of grid power, ownership, vehicular access and security. The site included the State of California owned 3-acre parcel (APN# 105-02-002) managed by Del Norte County for boat launch and river access. Alexandre EcoDairy Farms, owners of land on the opposite side of the river, granted access for the study so the two DIDSON units could operate between the opposing river banks.

Smith River DIDSON Station Operation

The Smith River DIDSON Station included small building connected to grid power, two Long Range DIDSON packages, 200-foot device communication cables, two laptop computers, point-to-point wireless bridge network components, a bank of 12v deep cycle batteries, and a motorized boat to maintain units. DIDSON units were deployed with “H” mounts submerged near river banks and positioned facing each other from opposite sides of the river to ensnare a cross section of the river channel (Figure 3). The right bank sonar and components were hardwired into the computer network. The remotely operated left bank sonar was connected to the network with the point-to-point wireless bridge (Figure 4). Right bank and left bank DIDSON units were operated simultaneously with one laptop computer (Dell Latitude E5510) and a 17-inch laptop computer was used for data analyses. Data were recorded 24 hours per day, stored in 20 minute files and saved in weekly file folders. Data were analyzed onsite with Sound Metrics DIDSON software version

5.23 and all data and analyses were saved to 2-terabyte (TB) drives and backed-up to a second set of drives through a computer to computer network.

DIDSON Deployment

We chose the simple and inexpensive H-mount design, made of schedule 40, 2-inch aluminum pipe with fittings that allow for easy assembly and adjustment (Figure 5). Units were attached to H-mounts using RAM double socket parts for easy sonar adjustment. An Alaskan weir was used on the left bank in order to prevent fish from swimming behind the unit during high flows (Figure 6).

Counting Fish with DIDSON

All recorded data was processed and analyzed for a complete census and fish counts were organized into a database for future systematic sampling investigations. A copy of the data was created each week for data processing, quality control and archiving. DIDSON files and Excel spreadsheet files were stored in weekly file folders. Count data from a single data collection week from both banks were combined to form weekly count data Master file workbooks. Within each master workbook, count data was organized by the bank and day of collection. The total time per day *fished* by bank was recorded for the calculation of fishing-efficiency, or how many hours and minutes of data was actually recorded with two sonars per day.

Fish were counted and recorded as Upstream Migrants or Downstream Migrants if they passed completely through the sonar beam array. Fish were not counted if they entered or exited the array without completely passing the upstream and downstream boundaries of the array. We used this method to avoid counting fish again with the other DIDSON or double counting fish swimming in and out of the sonar beam array. Only fish measuring greater than approximately 50 cm were counted as adults. Files containing more than 50 fish were counted several times and the average count was recorded. The Zoom and Measure tools in the software were used to distinguish small fish from larger fish (>50cm), and fish from mammals and birds. Files were processed with the Convolved Samples Over Threshold (CSOT) function to remove *blank* file portions before counting.

We used the following simple flux model described by Xie et al. (2002) to estimate total upstream movement of adult anadromous fish observed with DIDSON (*in* Cronkite et al. 2006).

$$N = U - D \tag{1}$$

where N = the net upstream flux, U = the upstream actively migrating fish and D = the downstream actively migrating fish. Migrant fish, or fish that are not actively migrating, can also be accounted for in this model, provided these fish eventually move upstream through the ensonified area (Cronkite et al. 2006). Since steelhead are iteroparous, spawned-out fish or kelts, have to be removed from the downstream estimate since the model relates only to actively migrating fish, and kelts would have been included in the spawning population as upstream fish. Summed over a 24 hour period, this model produces daily escapement estimates that are compiled to estimate the total spawning population entering a river.

The efficiency of the DIDSON station operation (fishing efficiency) was calculated with respect to the actual time data were recorded per day versus total possible time data could be recorded. Fishing efficiency was calculated for each unit as follows.

$$E = \frac{R+B}{T} \quad (2)$$

Where E = fishing efficiency, R = total right bank sonar file time recorded, B = total left bank sonar file time recorded, and T = 48 hours.

A sampling rate of 20 minutes per hour was applied to the data set in order to investigate the error associated with a static sampling rate throughout the season. The first, second and third 20 minute intervals of the hour were included in the investigation and kelts (downstream fish) were not removed.

Comparing Rowdy Creek Fish Hatchery Weir Counts to DIDSON Fish Counts

The Rowdy Creek Fish Hatchery provided all of the daily data collected from their barrier weir on Rowdy Creek for the study period. Data were organized in spreadsheets and compared with daily data from the Smith River DIDSON Station.

Measuring fish with DIDSON

Length measurements were made by merging CSOT processed files from a 24 hour period every 7 days from 16 Dec 2012 through 28 Mar 2013. An echogram was created for each of the merged files and procedures outlined in the DIDSON manual were used to manually measure the total length of each fish (Figure 7). Every fish image was analyzed though not every fish (e.g. less than 50 cm) was included in the count.

RESULTS

Counting Fish with DIDSON

The DIDSON station operated continuously for 108 days during the Smith River steelhead run-time from 14 Dec 2012 to 31 Mar 2013. A total of 9,562 fish were counted passing upstream and 784 fish were counted passing downstream (Figure 8, Table 4). Fish counted passing downstream were assumed to be steelhead kelts and were not subtracted from the upstream count. The highest daily count of fish passing upstream by the DIDSON station was 338 fish on 24 January. Highest weekly counts of upstream fish occurred during the week of 22 December and 23 January with 2,122 fish and 1,359 fish, respectively. The ratio of downstream fish to upstream fish increased from 0.02 in late December to 2.65 in late March (Figure 9). This trend was also observed during the Smith River DIDSON Pilot Study from 2010 to 2012 (Larson 2013). The recording efficiency of the DIDSON station operating continuously 24 hours per day over was 96%, up from 93% in 2012-2013 and 87% in 2010-2011, during the same time period. The application of a sampling rate of 20 minutes per hour yielded the lowest percent error during February (0.1) and highest percent error during March(24.4) (Table 5).

Comparing Rowdy Creek Fish Hatchery Weir Counts to DIDSON Fish Counts

Rowdy Creek Fish Hatchery weir counts provided species specific run time data that was compared to DIDSON data. The timing of peaks of upstream fish passage at the DIDSON Station closely resembled the timing of peaks of steelhead passage at the Rowdy Creek weir (Figure 10). Major peaks at both facilities occurred on 25 December, 24 January, and 07 March. During the operation of the DIDSON Station eight Chinook salmon and 577 steelhead were counted crossing the Rowdy Creek weir. With the exception of one Chinook captured at the Rowdy Creek weir on 27 January, Chinook were captured at the Rowdy Creek weir between 16 December and 30 December. No coho salmon were observed at the weir.

Measuring Fish with DIDSON

Length frequency measurements were greatly improved during the 2012-2013 season due to the addition of the large lens set. The total lengths were measured for 776 fish throughout the season (Figure 11). The average length of fish measured was 73.6 cm and lengths ranged from 15.6 cm to 138.4 cm or approximately 6 - 54 inches. The average length of fish by week was highest in February (78 cm) and lowest in March (64 cm) (Figure 12).

DISCUSSION

This study follows the Smith River DIDSON Pilot Study (2010-2012) that resulted in sonar fish counting station infrastructure and design and two full seasons of Chinook salmon and steelhead escapement information (Larson 2013). Due to limited funds available for an entire season of Chinook and steelhead monitoring in 2012-2013 and because winter steelhead have a relatively discrete run-time in the Smith River, a start date of 15 December was chosen in order to capture the relatively discrete run-time of Smith River winter steelhead. Results from our study should be viewed as a benchmark for steelhead escapement from 15 December -31 March rather than a measure of total annual escapement. Preliminary total annual steelhead escapement estimates from the Smith River DIDSON Pilot Study were 15,500 steelhead in 2010-2011 and 14,200 steelhead in 2011-2012.

Smith River angler survey data and Rowdy Creek weir data illustrate Chinook salmon and steelhead run time overlap. Chinook salmon typically cease entering Rowdy Creek mid-December and the vast majority of adult salmonids migrating into the Smith River later than mid-December are steelhead (Andrew Van Scoyk pers.comm.). Coho salmon also overlap with Chinook and steelhead but are estimated to be in the hundreds of individuals in 2011 and 2012. Coho salmon were assumed not to significantly influence the DIDSON census and therefore are not considered in the counts. Apportioning species during periods of species run-time overlap may be accomplished in the future through physical means, or video during periods of adequate visibility.

The 2012-2013 DIDSON data were compared to Smith River DIDSON Pilot study data from 2010-2012 and annual fish abundance for the 3-year period was similar in magnitude (Figure 13). During the December through March time period approximately 11,800 upstream fish were counted in 2010-2011, 12,800 fish were counted in 2011-2012, and 9,600 fish were counted in 2012-2013. The results from the three years of continuous data collected by DIDSON after 15 December indicate that the 2012-2013 steelhead run was slightly smaller than the 2010-2011 and 2011-2012 steelhead runs. This is contrary to the pilot study's escapement estimates described above.

The addition of the large lens fitted to the left bank long range DIDSON unit operating at high frequency improved the sonar image resolution and reduced an apparent positive bias experienced while measuring fish without the large lens during the 2010-2012 pilot study. In order to investigate potential length measurement bias at different ranges, equipment and environmental conditions it is recommended that tethered, live fish measuring experiments, similar to Burwen et al (2007) be explored.

This study confirms that multi-beam sonar technology used to quantify anadromous fish escapement in large rivers can perform better than standard methods and produce abundance and behavior information that is otherwise unattainable with standard methods. In addition, fixed location sonar fish counting stations can monitor populations in real time and allow managers to assess management decisions and respond accordingly.

No other basin-wide escapement estimates for steelhead have been ventured on the Smith River, or on other large rivers in California, other than the educated guesses by biologists in the 1960s. Overall, DIDSON is a valuable tool for assessing the magnitude of anadromous fish migrations, and therefore status and trend information, regardless of species apportionment constraints faced with the presence of protected species. Although the technology has limitations with respect to discriminating between salmonid species and identifying fish of hatchery origin, DIDSON can provide accurate information about the magnitude of salmonid escapement in the Smith River and help overcome precision and bias issues associated with spawning ground surveys. When used in conjunction conventional fisheries sampling techniques, DIDSON should reduce the uncertainty associated with current status assessments of imperiled species, help tease out ocean conditions and other climatic factors affecting populations, and improve the management of existing recreational, tribal and commercial fisheries. Long term funding is needed for monitoring Smith River anadromous fish populations with DIDSON.

TABLES

Table 1. Status of Chinook salmon, coho salmon and steelhead in the Smith River Basin.

Species	Evolutionary Significant Unit (ESU) and description	ESA/CESA Status
Chinook salmon	Southern Oregon Northern California Coast (Cape Blanco to Klamath River)	Not Warranted
Coho salmon	Southern Oregon Northern California Coast (Cape Blanco, OR to Punta Gorda, CA)	Threatened
Steelhead	Klamath Mountains Province (Cape Blanco, OR to Klamath River, CA)	Not Warranted

Table 2. Salmon and steelhead run-size estimates for northern California rivers (USFWS, 1960).

River Basin	Chinook salmon	Coho salmon	Steelhead
Smith River	15,000	5,000	30,000
Klamath River	100,000	20,000	400,000
Redwood Creek	5,000	2,000	10,000
Mad River	5,000	2,000	6,000
Eel River	25,000	15,000	100,000
Mattole River	5,000	2,000	12,000

Table 3. General adult migration times for salmon and steelhead in the Smith River.

Species	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct	Nov	Dec
Chinook salmon	■							■	■	■	■	■
Coho salmon	■										■	■
Winter steelhead	■	■	■	■							■	■

Table 4. 2012-2013 weekly counts of fish passing the DIDSON station and efficiency of operation.

Week	Upstream Migrants	Downstream Migrants	Total Upstream Migrants	Weekly Fishing Efficiency
Dec. 14 - 21 2012	768	56	712	74.78733%
Dec. 22 - 29 2012	2122	51	2071	95.01302%
Dec. 30 - Jan. 6 2013	974	53	921	98.25087%
Jan. 7 - 14 2013	947	56	891	98.14670%
Jan. 15 - 22 2013	435	21	414	98.62847%
Jan. 23 - 30 2013	1359	92	1267	95.61198%
Jan. 31 - Feb. 7 2013	561	37	524	98.78472%
Feb. 8 - 15 2013	601	30	571	98.77604%
Feb. 16 - 23 2013	326	22	304	98.80642%
Feb. 24 - Mar. 3 2013	601	75	526	98.92361%
Mar. 4 - Mar. 11 2013	590	106	484	99.28447%
Mar. 12 - Mar. 19 2013	124	63	61	99.22743%
Mar. 20 - Mar. 27 2013	154	122	32	98.87587%
Mar. 28 - Mar. 31 2013	59	162	-103	99.64409%
Running Totals	9562	784	8778	96.39361%

Table 5. The percent error by month associated with 20 minute per hour sampling rate. Downstream fish or kelts were not removed.

	Estimated Steelhead Monthly Counts and Error							
	Actual Total Count	Total Using First 20 min. of Each Hour	% Error	Total Using Second 20 min. of Each Hour	% Error	Total Using Third 20 min. of Each Hour	% Error	
Dec. 14- Dec. 31	3008	2859	5.0%	3210	6.7%	2955	1.8%	
Jan 1-Jan. 31	3371	3477	3.1%	3195	5.2%	3441	2.1%	
Feb. 1-Feb. 28	1522	1497	1.6%	1548	1.7%	1521	0.1%	
Mar. 1- Mar. 31	774	963	24.4%	759	1.9%	600	22.5%	
Total	8675	8796	1.4%	8712	0.4%	8517	1.8%	

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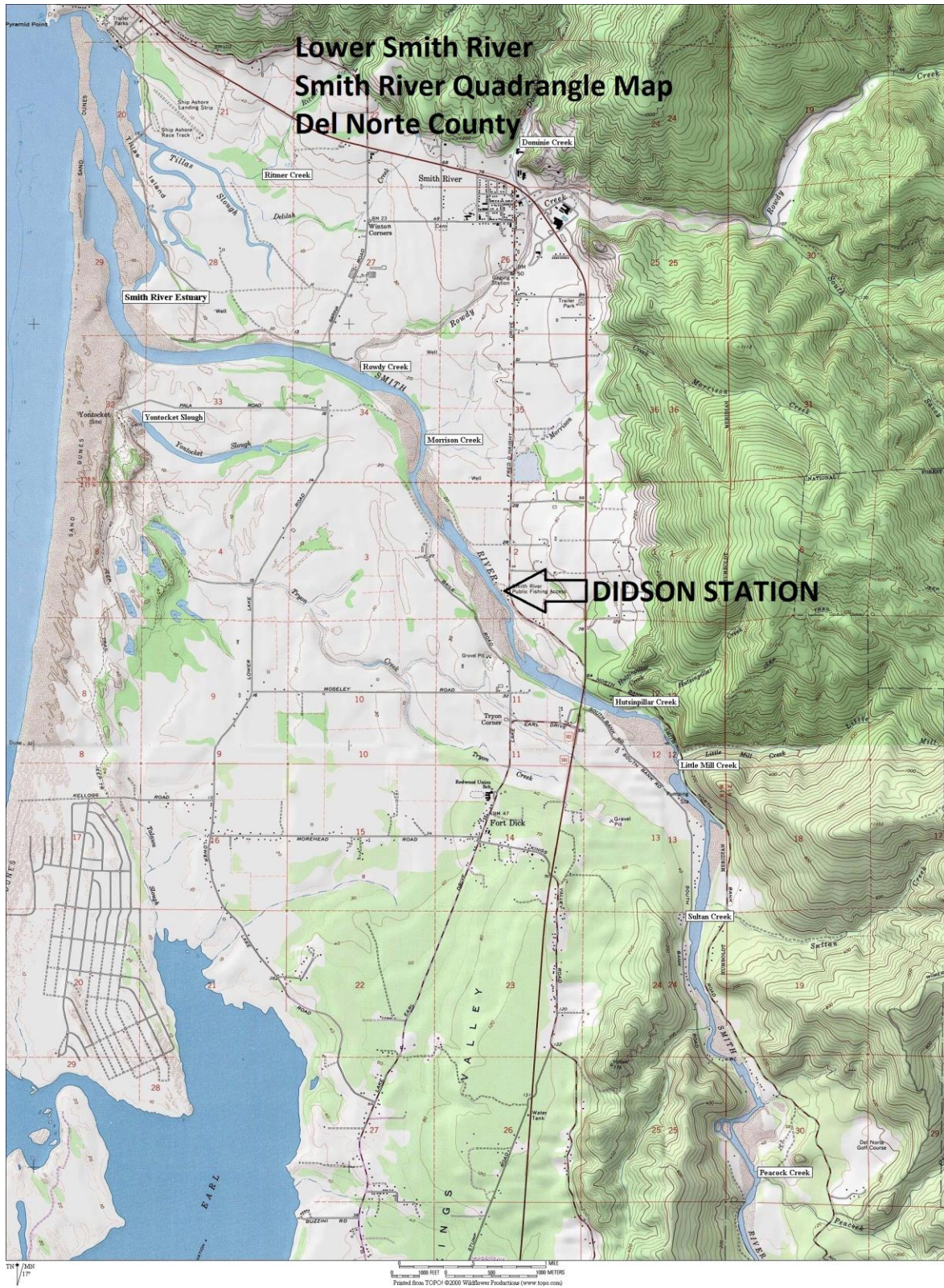


Figure 2. Location of the Smith River DIDSON Pilot Study facility location at river mile 6 near the town of Smith River, Del Norte County, California.

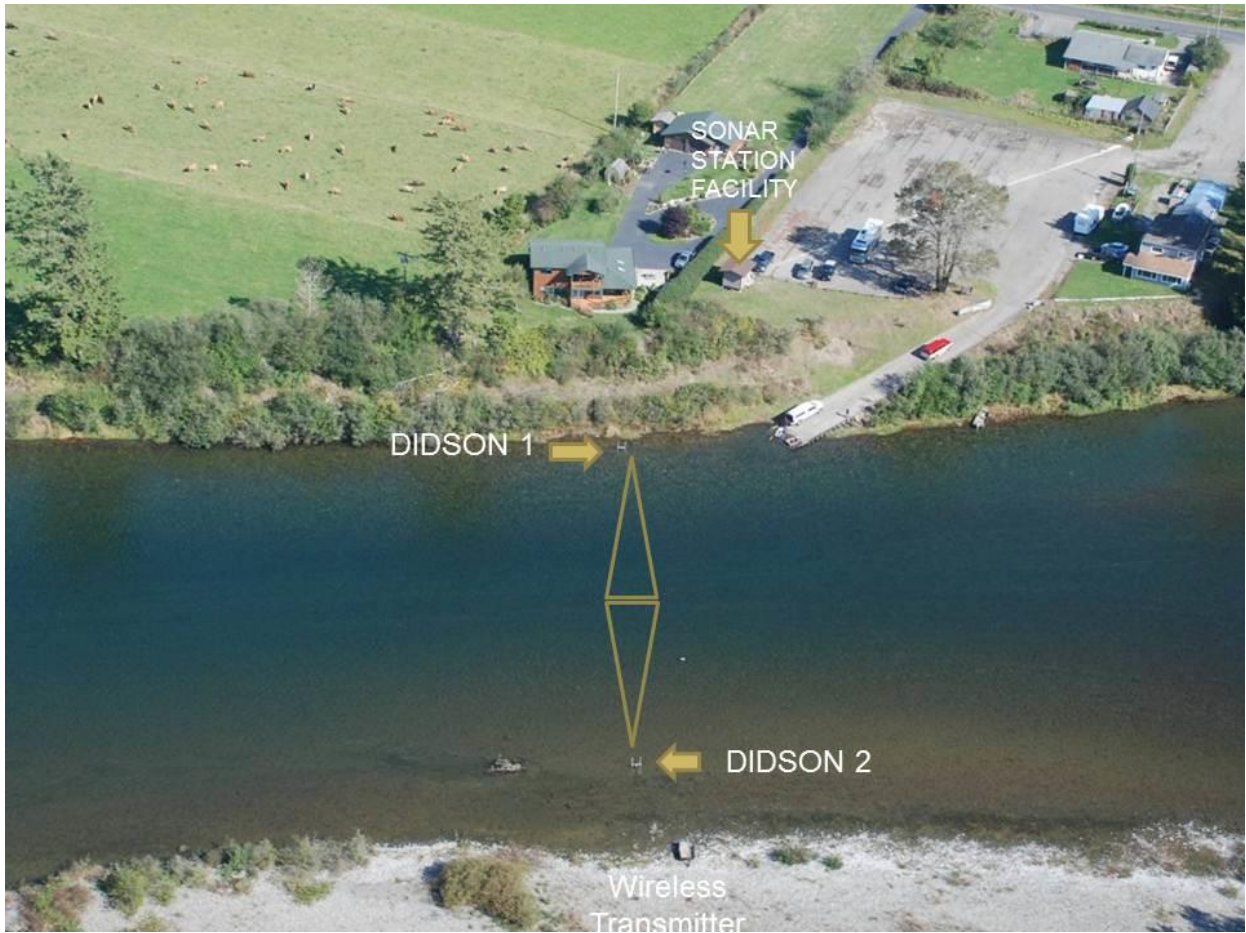


Figure 3. Aerial view of the Smith River DIDSON Pilot Study site and facilities at the public boat launch facility located at river mile 6. DIDSON 1 is located on the right bank and DIDSON 2 is located on the left bank. (Photo by Justin Garwood, CDFW).



Figure 4. Left bank DIDSON power and communication box showing configuration of the batteries, inverter, topside box and wireless router (right) and antenna (left).



Figure 5. DIDSON H-Mount design for the Smith River right bank location constructed from aluminum pipe and fittings. The aluminum plate was fabricated and welded to the crossbar and attached to a RAM double socket ball joint to accept the DIDSON unit.



Figure 6. Left bank DIDSON showing the Alaskan Weir, H-Mount and remotely powered wireless communication box.

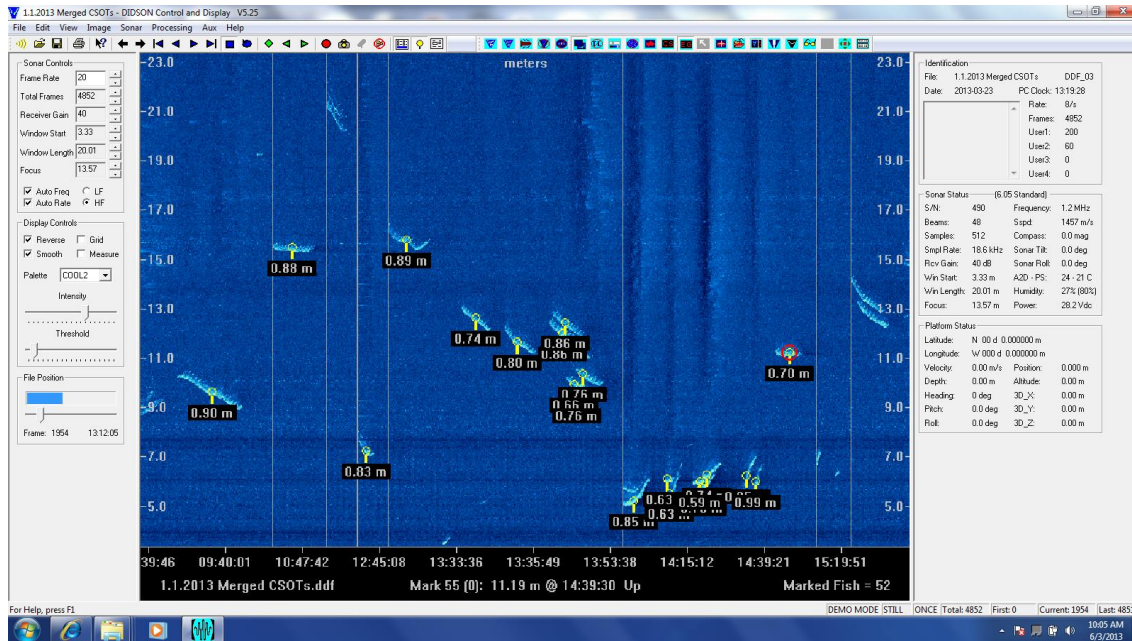


Figure 7. Computer output of manual fish measurements using the echogram function.

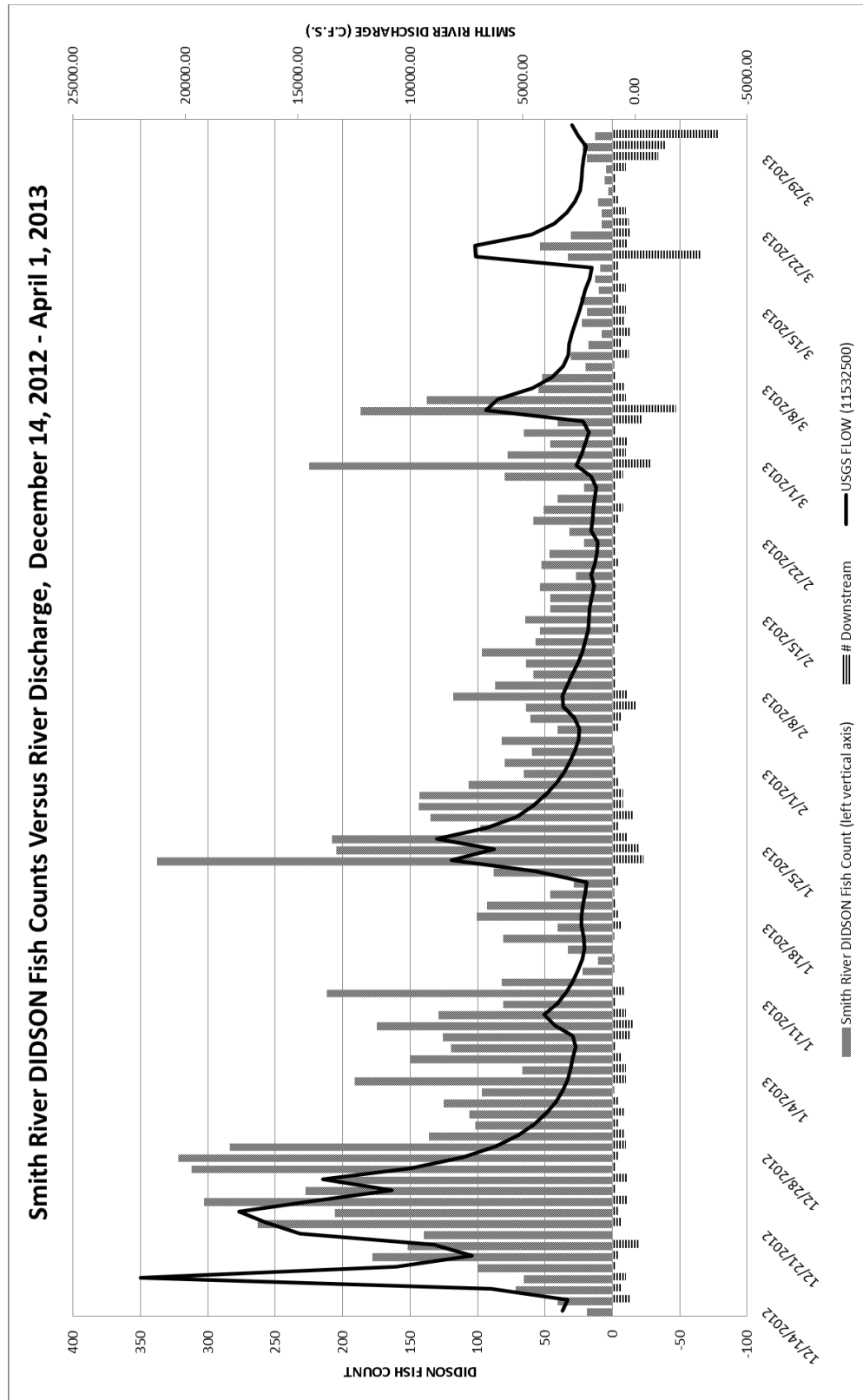


Figure 8. Daily fish counts at the Smith River DIDSON Station compared to stream gauge data.

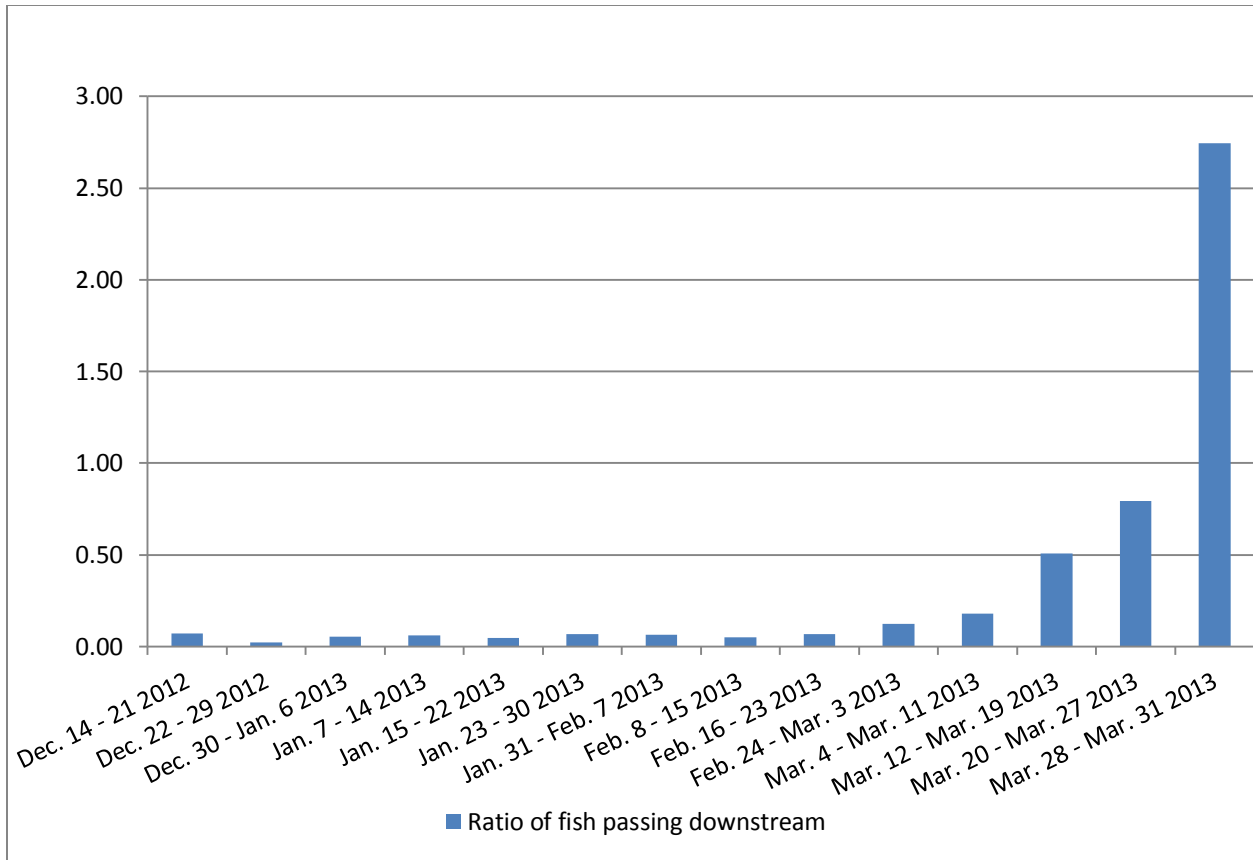


Figure 9. Ratio of downstream fish to upstream fish passing the DIDSON station. The rapid increase in the ratio of downstream to upstream fish is due to the steelhead kelt migration.

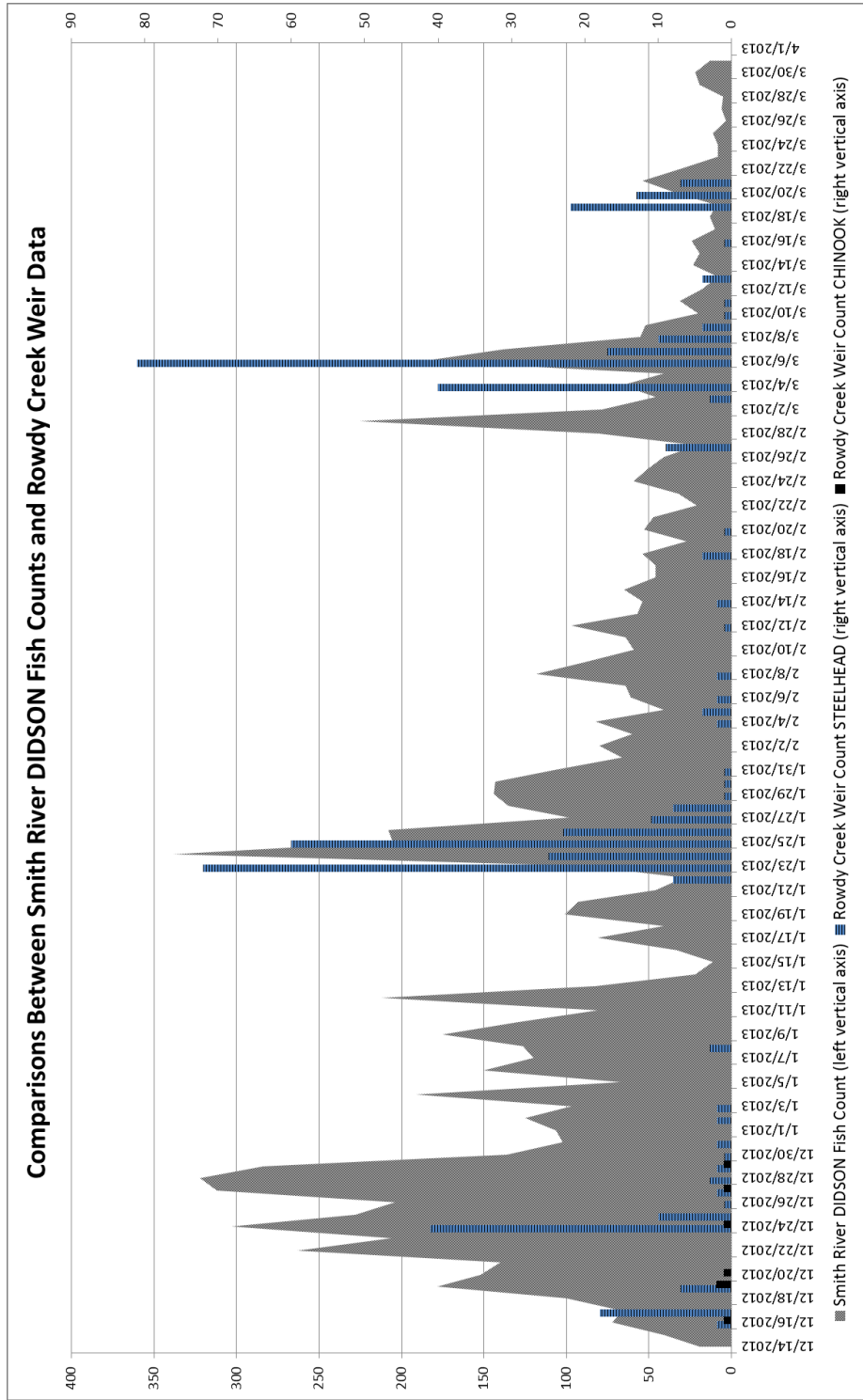


Figure 10. Run Timing: Rowdy Creek Fish Hatchery weir counts of Chinook and steelhead compared to Smith River DIDSON Pilot Study Data, 2012/2013. The shaded portion of the chart is DIDSON data corresponding to the left axis while the bars represent RCFH fish and correspond to the right vertical axis.

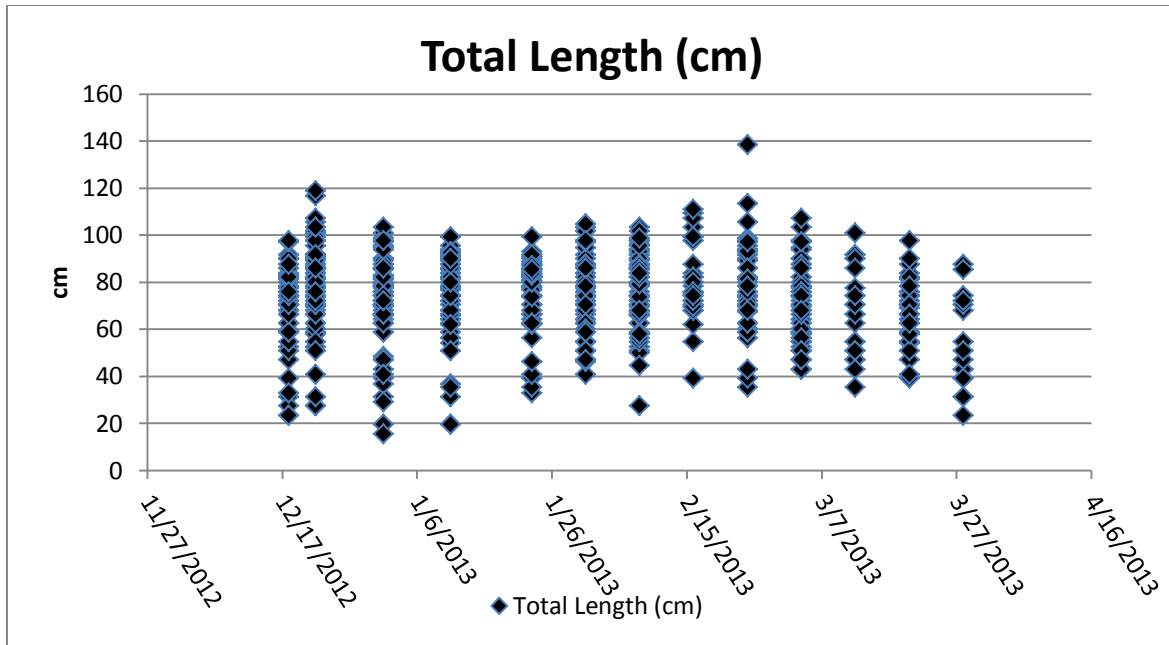


Figure 11. Fish lengths from a Long Range DIDSON fitted with large lens measured during the 2012-2013.

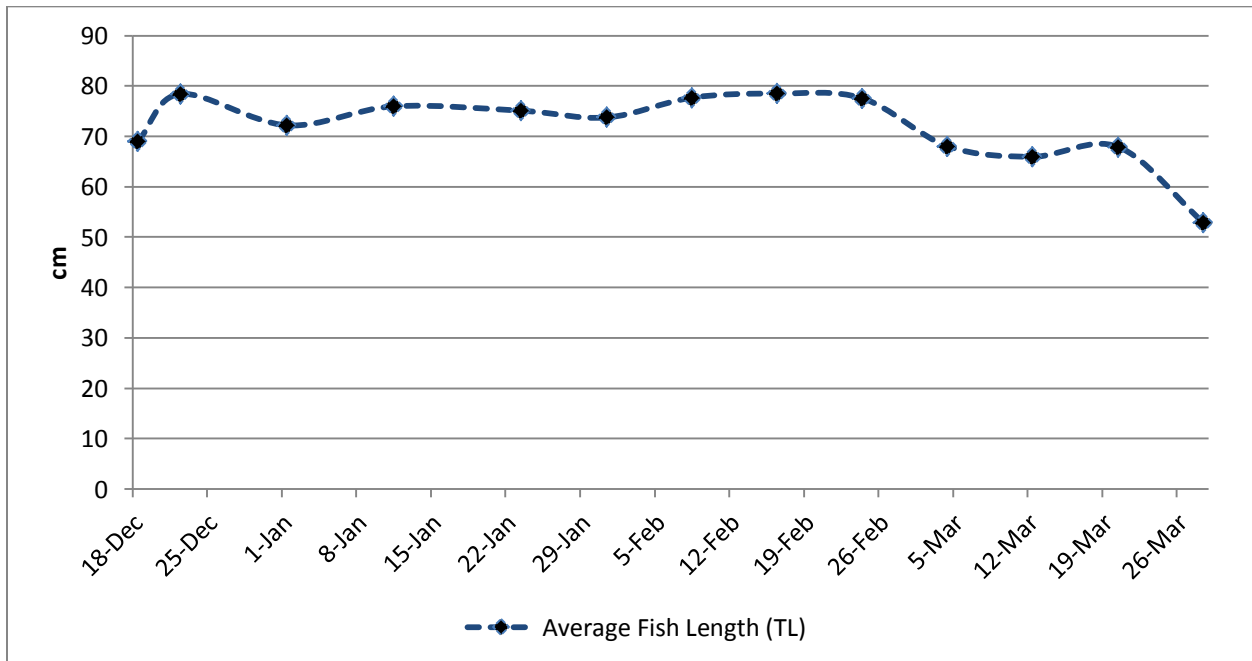


Figure 12. Weekly averages of total lengths of fish measured with DIDSON.

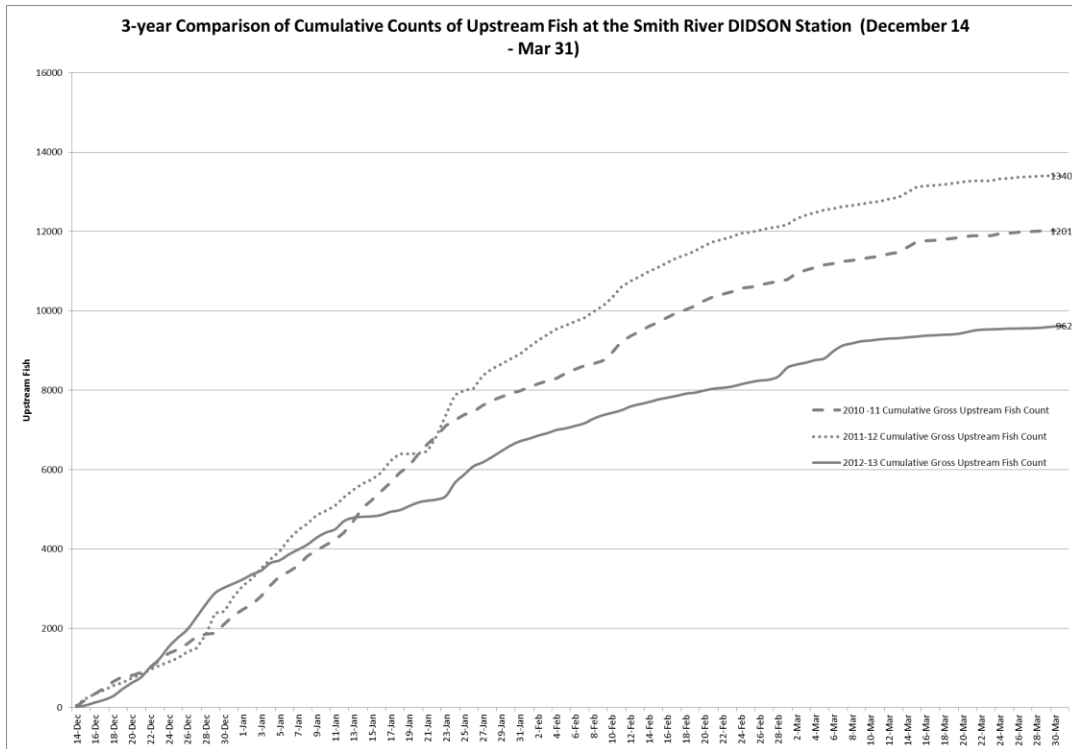


Figure 13. Cumulative fish counts from the Smith River DIDSON Station 14 December – 31 March, 2010-2013.



Figure 14. Left bank DIDSON deployment showing the large lens installed.

APPENDIX

Status of fish species occurring or potentially occurring in the Smith River watershed.

SPECIES	ESU	STATUS ¹	
		Federal	State
Coho salmon (<i>Oncorhynchus kisutch</i>)	Southern Oregon/Northern California Coasts	T	T
Chinook salmon <i>Oncorhynchus tshawytscha</i>	Southern Oregon/Northern California Coasts	NW	CSC
Steelhead <i>Oncorhynchus mykiss irideus</i>	Klamath Mountains Province	NW	None
Coastal cutthroat trout <i>Oncorhynchus clarki clarki</i>	Southern Oregon/California Coastal	NW	CSC
Chum salmon <i>Oncorhynchus keta</i>	Pacific Coast	NW	None
Green sturgeon <i>Acipenser medirostris</i>	N/A	C2	None
River lamprey <i>Lampetra ayresi</i>	N/A	C2	CSC
Pacific Lamprey <i>Lampetra tridentata</i>	N/A	C2	None

T Threatened
 NW Not warranted for listing
 CSC CDFG and/or California Board of Forestry Species of Concern
 C2 Species formerly classified as Category 2 candidates by the USFWS; these species no longer have a legal federal status
 CE Candidate to be listed as endangered pursuant to the California Endangered Species Act.