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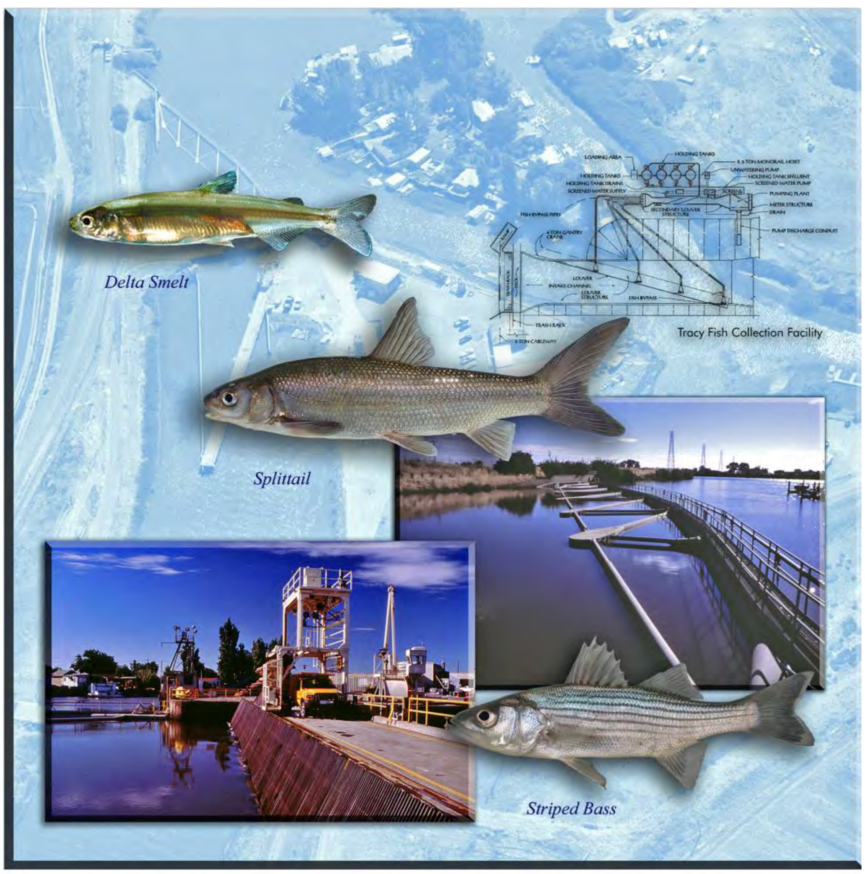
Tracy Technical Bulletin 2012-1

Effectiveness of Fine Mesh Screening a Holding Tank in Retaining Larval and Juvenile Fish at the Tracy Fish Collection Facility



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14. ABSTRACT
Operations and infrastructure at the Bureau of Reclamation's Tracy Fish Collection Facility (Byron, CA) function to divert, collect, hold, and transport salvaged fish to the central Sacramento-San Joaquin Delta (SSJD), and away from water pumping facilities. Fish are diverted from entry into the Delta Mendota Canal (DMC) and are collected and held in circular recessed holding tanks. The holding tank screen retains fish in the holding tank while allowing water to flow through the screen and back to the DMC; however, holding tank screen retention of larval fish is 60% (± 9.9) for 10–20 mm larvae and as low as 9% for larvae <10 mm which could contribute to significant entrainment losses of larval SSJD fishes. In an effort to reduce further small fish loss, implementation of a 0.5 mm Nitex® (Sefar, Inc.) screen, a durable nylon screen, wrapped around a holding tank screen, was examined. Holding tank lined with Nitex® screen retained significantly more small (4–20 mm) fish. Installation and maintenance of Nitex® screen had minimal impact on fish salvage. Nitex® screen retention of small fish will mean enhanced salvage.

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Tracy Fish Facility Studies
California

Effectiveness of Fine Mesh Screening a Holding Tank in Retaining Larval and Juvenile Fish at the Tracy Fish Collection Facility

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by

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TRACY FISH FACILITY IMPROVEMENT PROGRAM

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COVER

Fish photography by René Reyes, Tracy Fish Collection Facility, Tracy, California.
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EXECUTIVE SUMMARY

The Bureau of Reclamation's Tracy Fish Collection Facility (Byron, CA) diverts, collects, and holds salvaged fish that are transported to the Sacramento-San Joaquin Delta (Delta). Fish are diverted from entry into the Delta Mendota Canal and the C.W. "Bill" Jones Pumping Plant (JPP) and are collected and maintained in cylindrical recessed holding tanks. The holding tank screen is critical because it functions to retain live fish salvaged in holding tanks prior to truck transport to the central Delta and away from the immediate influence of the JPP.

Small, streamlined, fusiform fish can go through the holding tank screen, which has an average square opening of 2.7 mm and an average diagonal opening of 3.8 mm. In an effort to find a means to reduce small fish loss, we tested the feasibility and effectiveness of a 0.5 mm durable nylon Nitex® (Sefar, Inc.) screen wrapped around a holding tank screen. The Nitex® screen was simple to install (mean installation time = 17 min) and remove (mean removal time = 5 min), and was durable enough to last the majority of a typical larval fish season (45 d) without replacement. Holding tank lined with Nitex® screen retained significantly more small (4–20 mm) fish. Greater retention of small fish will mean enhanced salvage.

INTRODUCTION

The Bureau of Reclamation's Tracy Fish Collection Facility (TFCF; Byron, CA) diverts and collects (salvages) millions of fish annually which are otherwise destined for C.W. "Bill" Jones Pumping Plant (JPP; Figure 1). There are multiple facility components that impact the fish salvage efficiency at the TFCF (DOI 1957; Hallock *et al*. 1968). The holding tank screen is one such component, as it functions to retain and maintain live fish salvaged in TFCF holding tanks prior to truck transport to the central Sacramento-San Joaquin River Delta (Delta) and away from the immediate influence of the JPP. The holding tank screens typically have 10 cfs of water continually passing through. Because of seasonally high debris loads that would contribute to failure of fine-mesh screens and the difficulties associated with seasonally replacing the existing stainless steel screens, it is necessary to consider using cost efficient screen materials that could easily be secured over the existing holding tank screen.

The 7.8 ft (2.4 m), 15.5 ft (4.7 m) tall, stainless steel holding tank screen (Figure 2) has a wire average diameter of 2.1 mm (range: 2.0–2.1 mm), an average square opening of 2.7 mm (range: 2.4–2.9 mm) and an average diagonal opening of 3.8 mm (range: 3.4–4.3 mm). Wu (unpublished 2012) demonstrated that small, streamlined, fusiform fish are not always retained by the holding tank screen (~27 % loss for 20 mm larvae, unpublished data). Since the current 2.4 mm minimum screen opening is equivalent to the maximum height of a delta smelt (*Hypomesus transpacificus*) with a length of ~23 mm (Sutphin *et al.* 2007), small fish loss through the holding tank screen is expected. Given that losses of larval and early-juvenile fish occur, including species like delta smelt and state threatened longfin smelt (*Spirinchus thaleichthys*), it is important to investigate means to decrease holding tank mesh size.

The primary objective of this study was to determine how effective a fine-mesh (0.5 mm) Nitex® screen (Sefar Inc., Depew, NY), a light weight and flexible nylon screen, retains larval and juvenile fish. A secondary objective was to test the efficacy of using Nitex® screen by recording the duration of installation and removal, the methods and frequency of cleaning, and the duration of collection (screen durability) before Nitex® screen failure (i.e., Nitex® screen tears or collapses).

METHODOLOGY

At the initiation of each replicate, a 2.3 m x 8.5 m (7.5 ft x 28 ft), 0.5 mm Nitex® screen was wrapped around the exterior of a holding tank screen [diameter: 2.4 m (7.8 ft), circumference: 7.6 m (25 ft)]. At the swim-up life stage, most larval fish have attained a body depth of >0.5 mm; therefore, we implemented a 0.5 mm Nitex® screen with the assumption that a screen this size will retain larval and

Figure 1.—Map of the Sacramento-San Joaquin River Delta depicting the Tracy Fish Collection Facility and C.W. ―Bill" Jones Pumping Plant.

juvenile fish <20 mm. The ends were overlapped in the direction of the water flow so water pressure kept the Nitex® screen secure against the holding tank screen. Three ropes encircled the Nitex® screen and were attached with bungee cords along the top, middle, and bottom of the holding tank screen (Figure 3). Installation time was recorded. In addition to the Nitex® screen around the holding tank, 0.5 mm Nitex® screen was also installed on the 2.5 mm perforated fish lift bucket, here upon called haul-out bucket, which was used to collect samples from the holding tanks.

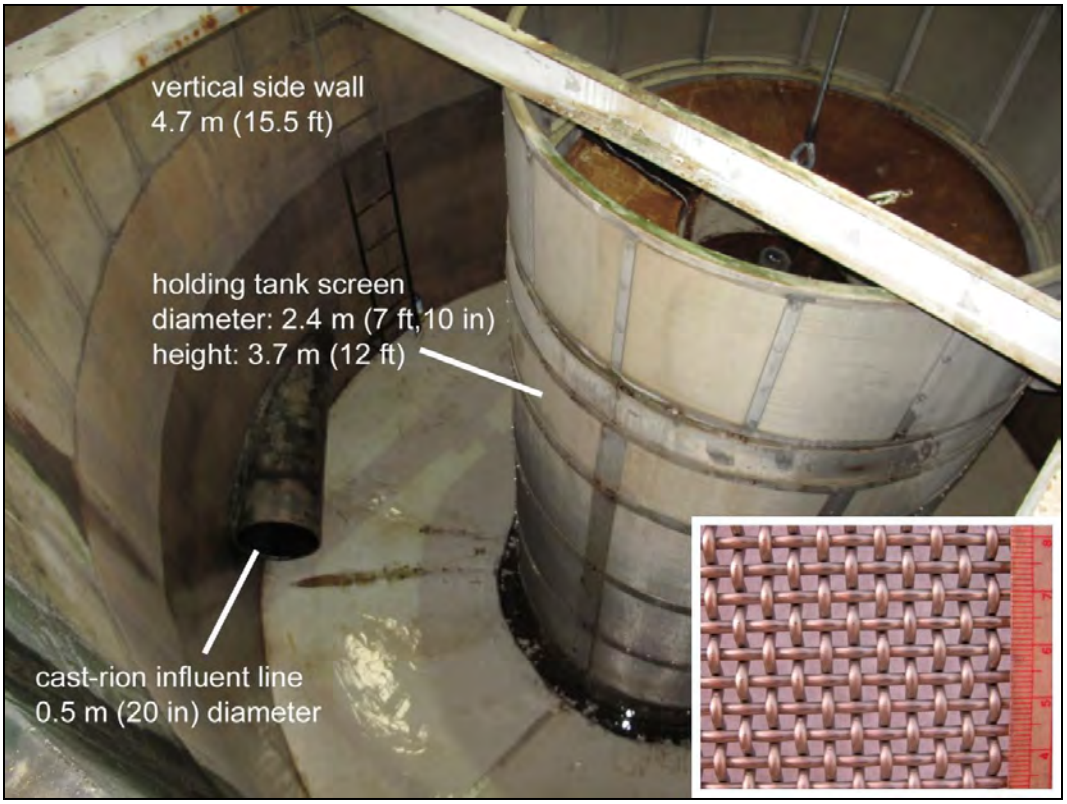

Figure 2.—Holding tank screen. *Inset*: Closeup of holding tank's stainless steel wire mesh with 2.7 mm average square opening.

Paired samples (n = 11) were collected from holding tanks wrapped with and without a Nitex® screen (HT_{Nitex}) between April 1 and June 10, 2009. Nitex® screen was installed in spring when debris loads were at their lowest levels and when larval fish were present. Sampling began after the evening haul-out and completed the following day before the morning haul-out, and constituted approximately eight hours of sampling. In order to assure pairing of samples, both holding tanks were sampling simultaneously. Flows of both holding tanks were recorded (N = 75) at the beginning and ending of each sampling trial and every even hour during the trial. Each tank was equipped with a DigitalFlow™ DF868 flow meter (GE Infrastructure Sensing, Inc., Billerica, MA) on the drain line, and similar tank flows were maintained by adjusting the drain valves. At the conclusion of each sample period, both holding tanks were turned off and drained simultaneously, followed by the removal of fish to the haul-out truck via the haul-out bucket. Before the fish were transferred to the truck, three 19-L buckets were used to take a subsample of surface-oriented swimming larvae and juveniles from the haul-out bucket. Subsamples were collected by quickly submerging the entire bucket and quickly removing it. Because the first subsample likely affected the following two subsamples, the second and third subsamples were collected consecutively from different points of the haul-out bucket. The haul-out bucket has a wide enough water surface area to allow at least three different points of sampling. Because we were subsampling for live swimming larvae and juveniles, we assumed fish that positioned themselves near the surface and in the water

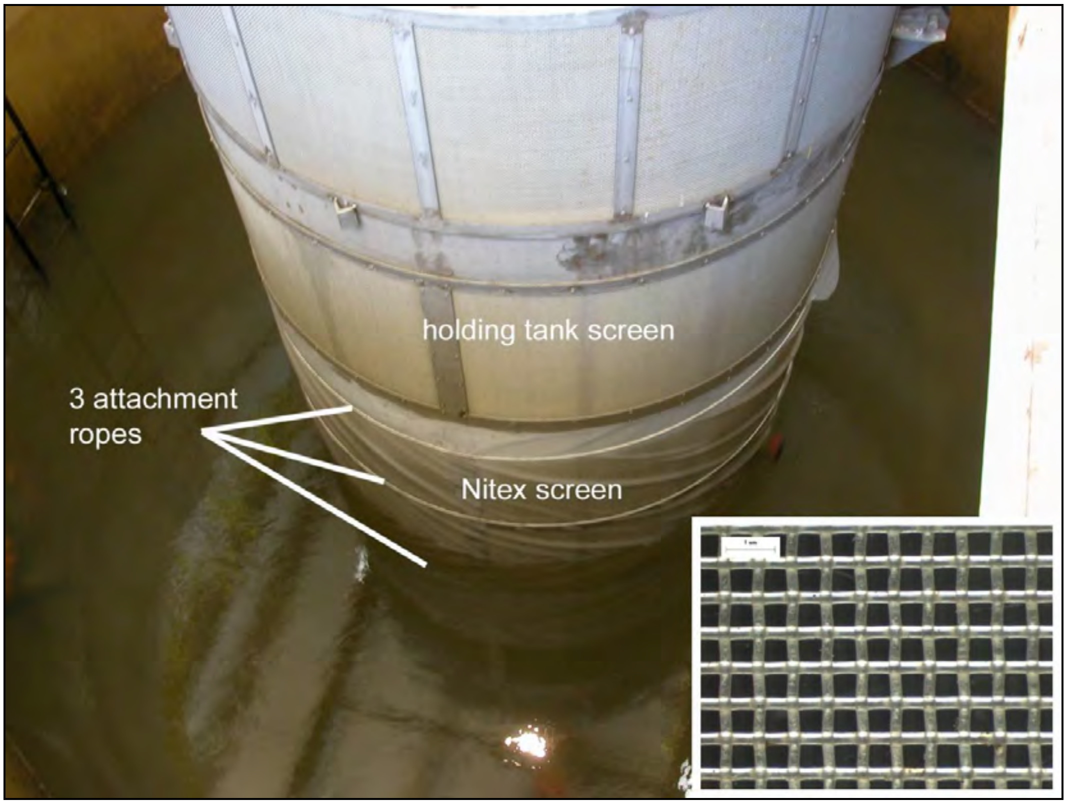

Figure 3.—Holding tank screen wrapped with a 0.5 mm Nitex® screen. *Inset*: closeup of Nitex® screen with 0.5 mm square opening.

column were alive. We targeted fish in this water column because this is where most larvae in the Delta are located and because most species of special concern are pelagic. We also assumed bottom-oriented larvae and dead larvae sink to the bottom and are not sampled. The holding tank screen receiving the treatment (i.e., HT_{Nitex}) was switched following each replicate to reduce tank effects.

Collected larvae and juveniles were stained with Rose Bengal and preserved using 10% buffered formalin. Each fish was identified to species, except for gobies in the genus Tridentiger, because not enough morphometric information is documented for positive species identification. Total lengths were measured with the aid of a Leica™ $MZ7_5$ stereomicroscope (Leica Microsystems, Bannockburn, IL).

To test durability of the Nitex® screen, it was installed in March 2012 in holding tank #3 where the majority of the salvage collection occurs (daily collection: ~18 hours) and was monitored until signs of collapse or tearing were observed. The Nitex® screen was cleaned using a high-pressure wash while holding tank #3 was drained at least twice a day for fish transport.

Data Analysis and Interpretation

Larval and juvenile fish retention data did not meet the assumptions to model using parametric statistics; therefore, Wilcoxon Signed Rank Test, a non-parametric alternative to a paired t-test, was used. Effect of Nitex® screen on size (length) of fish retained, as well as differences within size class as a function of treatment, was analyzed using Two-Way ANOVA on Ranks. Tukey's Multiple Comparison Test was applied to test for differences in the means of size classes. Size classes were ≤ 5 mm, 5.1–10 mm, 10.1–15 mm, and 15.1–20 mm. The number of fish collected was converted to percentage to give each paired sample equal weight. Because there were collection days when 0 to 5 fish were present, a selection criterion was developed where only the days with > 5 fish within a size class on the particular day were accepted. To test for differences in water flow to both tanks during testing, we used a One-Way ANOVA on Ranks. All statistical analyses were conducted using SigmaStat 3.5 (Systat Software, Inc., Chicago, IL), with an alpha level of 0.05.

RESULTS AND DISCUSSION

A total of 3,746 larval and juvenile fishes were collected and measured, 103 hours of collection time was recorded, and 95,000 cubic meters (3.3 million cubic feet) of water were sampled. There was no significant difference in water flow going to the paired holding tanks (P = 0.381; Table 1). Applying the Nitex® screen resulted in a significant increase in the total number of larval and juvenile fish retained (P = 0.042; HT_{nitex} = 2,190 vs. $HT_{control}$ = 1,556; Table 2). Also, application of the Nitex® screen resulted in the retention of significantly more small larvae ≤ 5 mm (P<0.001) and 5.1–10.0 mm (P = 0.003).

Table 1.—Comparison of water flow (cfs) to holding tank without Nitex® screen ($HT_{control}$) and holding tank with Nitex® screen (HT_{nitex})

Treatment	N	Mean (cfs)	Std. Dev.
$HT_{control}$	75	5.43	0.49
HT_{nitex}	75	5.46	0.52

Samples were dominated (98%) by three species: prickly sculpin (*Cottus asper*), striped bass (*Morone saxatilis*), and a goby (genus *Tridentiger*), likely shimofuri goby (*Tridentiger bifasciatus*), the most common resident goby in the south Delta. Although both prickly sculpin and *Tridentiger* spp. are bottom-oriented as

Table 2.—Total and percentage of fish collected from the holding tank without Nitex® screen ($HT_{control}$) and holding tank with Nitex® screen (HT_{nitex})

Species	$HT_{control}$	Avg. size (mm)	HT_{nitex}	Avg. size (mm)	Total	Percent of Totals
Delta smelt *Hypomesus transpacificus*	1	25.4	4	15.9	5	0.1%
Longfin smelt *Spirinchus thaleichthys*	0	—	1	21.9	1	0.0%
Prickly sculpin *Cottus asper*	120	6.0	275	5.7	395	10.5%
Sacramento sucker *Catostomus occidentalis*	0	—	1	15.2	1	0.0%
Striped bass *Morone saxatilis*	192	11.9	316	12.1	508	13.6%
Goby *Tridentiger* spp.	1233	10.5	1569	10.6	2802	74.8%
Threadfin shad *Dorosoma petenense*	8	16.6	6	17.0	14	0.4%
American shad *Alosa sapidissima*	0	—	1	21.5	1	0.0%
White catfish *Ameiurus catus*	2	14.7	5	15.5	7	0.2%
Bigscale logperch *Percina macrolepida*	0	—	4	9.0	4	0.1%
Largemouth bass *Mircopterus salmoides*	0	—	2	13.1	2	0.1%
Crappie *Pomoxis* spp.	0	—	1	14.3	1	0.0%
Common carp *Cyprinus carpio*	0	—	3	7.7	3	0.1%
Inland silverside *Menidia beryllina*	0	—	2	4.0	2	0.1%
Total collected	**1556**		**2190**		**3746**	**100.0%**

juveniles and adults, both are pelagic during their larval stage and become demersal at about 15 mm TL (Broadway and Moyle 1978; Wang 2010). The dominance of three species should be considered when interpreting the data, as the experimental results and benefits of employing the Nitex® screen may not be applicable for all species of fish salvaged at the TFCF. Interestingly, HT_{nitex} did collect more species (14 vs. 6 species) than $HT_{control}$, even though the dominant species were proportionally the same across treatments. Assuming that Nitex® screen retains 100 % of all larvae and juveniles, fewer species collected in $HT_{control}$ may indicate that some species are lost through a holding tank screen without a Nitex® screen. Therefore, future experimentation, conducted when species other then prickly sculpin, striped bass, and *Tridentiger* spp. are dominant is warranted.

Nitex® screen decreased the average holding tank screen size (diagonal opening) from 3.8 mm to 0.6 mm and effectively decreased the size of fish that can be lost through the holding tank screen. There was no significant difference ($P = 0.110$) in mean fish length as a function of treatment; however, when evaluating retention by 5 mm incremental size classes, the holding tank with Nitex® screen retained significantly more small larvae ≤ 5 mm ($P<0.001$) and 5.1–10.0 mm ($P = 0.003$; Figure 4). The Nitex® screen improved the capture of these small fish < 10 mm TL, but not the larger fish > 10.1 mm TL. Differences at the

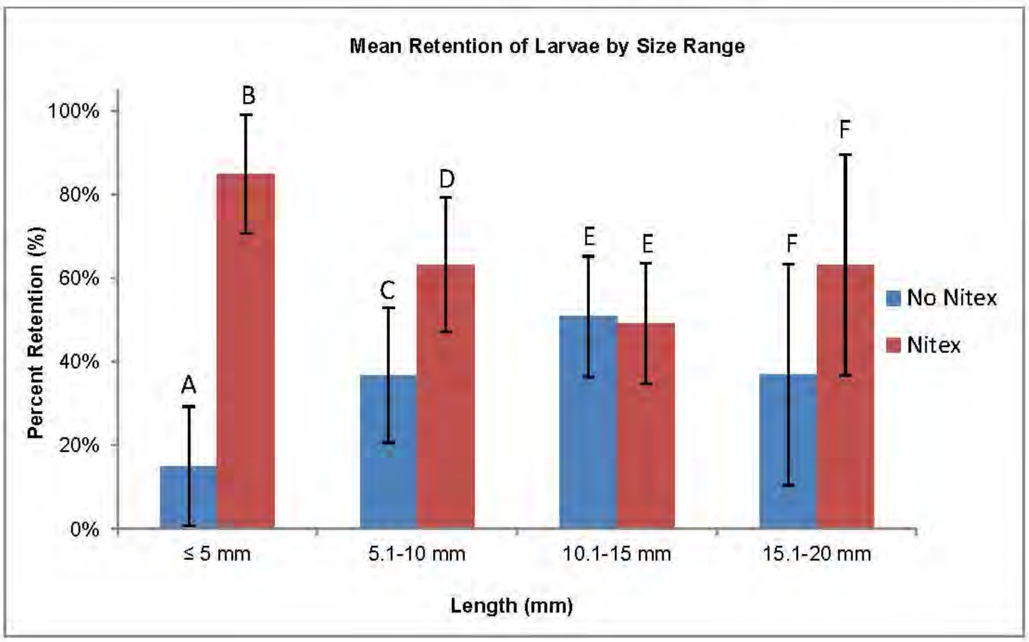

Figure 4.—Mean retention of larvae by size range: ≤ 5.0 mm (n = 5), 5.1–10.0 mm (n = 8), 10.1–15 mm (n = 2), and 15.1–20 mm (n = 4). Different letters above error bars (± standard error) indicate significant differences within size class averaged over species as function of treatment (Two-Way ANOVA, Tukey's Multiple Comparison Test).

10.1–15 mm and 15.1–20 mm size classes were expected but were not detected. Even though sampling did not demonstrate improved capture of larger fish, 10.1–15 mm ($P = 0.89$) and 15.1–20 mm ($P = 0.116$), it does not mean the Nitex® screen does not retain larger larvae. It is possible that larger fish were able to swim away from the subsampling bucket. Furthermore, the sample sizes for larger larvae > 10 mm were small; therefore, further data collection may be necessary to determine if differences truly exist.

Nitex® screen was durable, and was installed and removed with minimal impact on salvage operations. Salvage was halted during installation for an average of

17 minutes (range = 10–30 minutes) and during removal for <5 minutes. Since the Nitex® screen was cleaned with high pressure water at least twice a day, it was effectively cleared of algal growth and debris. A 1 m long tear was noticed on the 45th day of testing, and the Nitex® screen was removed the following day. The tear, located 0.3 m (1 ft) from the top of the Nitex® screen, was horizontal and suggested that it may have been caused by a snag (*e.g.*, fishing hook). Because the rest of the Nitex® screen was in good condition, it was likely that the screen could have been left in place for a much longer duration.

The Nitex® screen test also demonstrated that it is possible to collect salvaged fish in two holding tanks simultaneously. The main advantage of this process is that it reduces the water swirl speed and through screen velocity, both of which need to be minimal for small fish.

RECOMMENDATIONS

Nitex® screen should be installed for four months of the year, February to May, during the larval season when debris load is minimal. February is when the newly hatched osmerids such as delta smelt and longfin smelt are usually detected, April is when larvae of native species are detected, and May is when striped bass larvae are detected (California Department of Fish and Game salvage). Keeping the Nitex® screen past May will only benefit introduced species such as centrarchids (sunfish) and ictalurids (catfish). The current holding tank screen has a mesh opening that fishes with lengths in the mid-20 mm can pass through, including juvenile delta smelt and longfin smelt. By installing a 0.5 mm Nitex® screen around the holding tank screen when juveniles of these species are present in the system, the TFCF can potentially help increase their numbers in the Delta. A Nitex® screened holding tank will also benefit other species that are economically important to the region such as striped bass and native species such as prickly sculpin.

Our objective was to determine how well a holding tank with 0.5 mm Nitex® screen retains larval and juvenile fishes; however, our study did not measure the long-term survival of these retained fishes. This should be the focus of another study. It is important to note that the Nitex® screen likely retained smaller debris that would have otherwise filtered through the holding tank screen. Since we did not quantify debris, the effect of fine debris on the survival of small fish can only be speculated.

It might be prudent to quantify the benefits [*e.g.*, affordable temporary screen ($1,200), increased larval fish salvage, greater sensitivity detecting rare species] versus the negative effects (*e.g.*, increased take, potentially decreased pumping) of using the Nitex® screen. Currently, larval sampling at the TFCF is conducted seasonally in order to detect the presence of larval delta smelt and longfin smelt at the south Delta. During this sampling process, only the count station screen has a 0.5 mm mesh. By employing Nitex® screening on all holding tanks, a more accurate picture of when osmerid larvae are present can be obtained; however, it will also increase the facility's take. Nitex® screened holding tank can be used to collect larval and juvenile delta smelt for ecological monitoring or used for laboratory-based ecological experiments to complement those conducted at the U.C. Davis Fish Conservation and Culture Laboratory.

Nitex® screen should be readjusted every two weeks to check for biofouling and damage. An easier method of attachment to supplement or in lieu of ropes and bungee cords should be developed.

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