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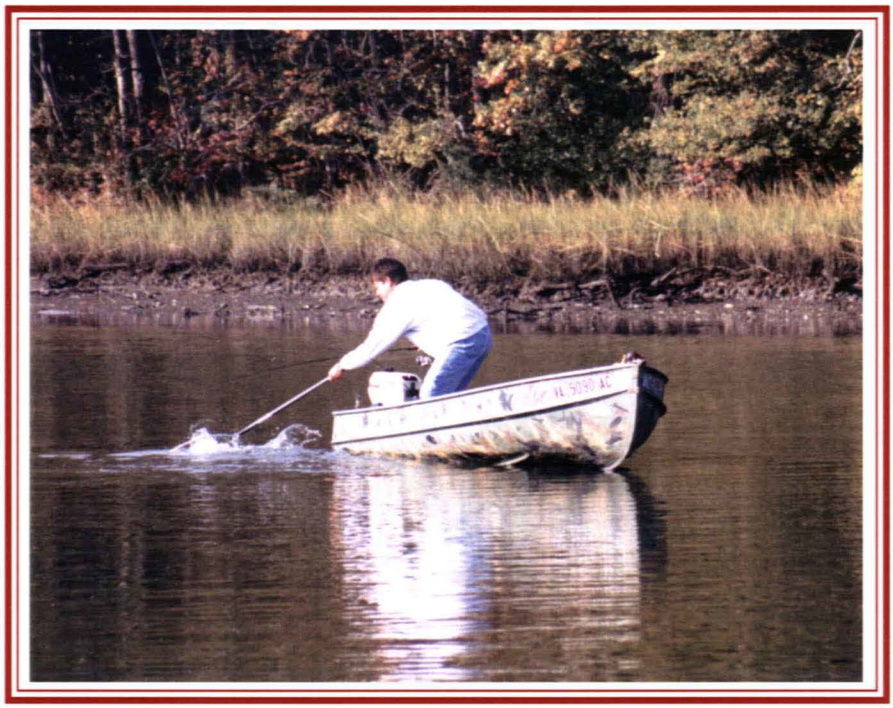
Progress Report



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Virginia Marine Resource Report No. 2003-03
VSG-03-12

April 2003

WILLIAM & MARY VIMS
VIRGINIA INSTITUTE OF MARINE SCIENCE
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Sea Grant
Virginia

SALTWATER RECREATIONAL FISHING DEVELOPMENT FUND

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Finally, thanks go to Claude Bain for his insight and counsel regarding the many difficulties encountered during the course of the project.

All photos by J. Lucy except two, bottom left, page 1 (Credit: Cory Routh).

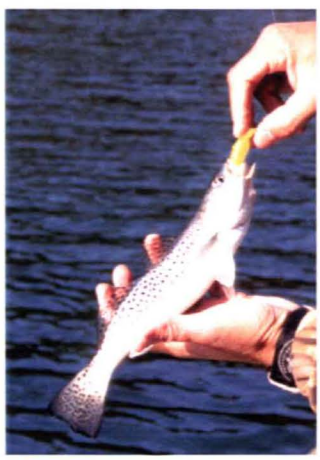
Summary

Spotted seatrout, *Cynoscion nebulosus*, are taken by anglers in Virginia's Chesapeake Bay using both bait-fishing techniques (mid-late spring) and artificial lures (fall). Experienced anglers indicate that the bait fishery could produce a 30-50 % rate of deep-hooked fish. This ongoing project is assessing short and longer-term, post-release mortality rates in fish evaluating J-shaped and circle hooks, as well as artificial lures.

Fishing trials (2000-2002) have resulted in catching and holding nearly 400 fish, with sizes ranging from 10-22 in (254-559 mm) total length. Short-term release mortality rates were minimal, consistently ranging from 3.5-4.2 % for lure caught fish (3-7 day post-capture holding periods; average period = 4 days). These mortality rates are as low as, or better than, those observed in similar projects conducted in southeastern states (1991-1996). Because of inconsistencies in fish abundance to date, no useful release mortality data have been collected on bait-caught fish. The purpose for requesting to extend the project through 2003 is to collect this data for comparison with results on lure-caught fish.

Experimental tracking trials, exploring acoustic tracking and other telemetry methods involving tethering small, low-drag plastic floats to fish, have been completed on over 15 fish. However because acoustic tag detection ranges vary considerably (200-1000 ft/60-305 m) in shallow water/SAV habitat, tracking to date has been largely limited to the tethered float method. Floats containing only radio transmitter tags, and floats containing these tags along with a small GPS unit have provided varying degrees of detailed data on fish movement patterns.

Fish (16-26 in/406-660 mm), typically tracked for at least one overnight period, have moved distances of 0.5-6.1 mi over tracking times of 9-61 hr. This is significantly greater movement than found in tagging studies in North and South Carolina (usually one mile or less). Extending the project through 2003 will enable researchers to conduct a final series of tracking trials in which fish are tracked using both acoustic methods and tethered floats. This is necessary to determine whether the tethered float method possibly results in atypical movement patterns associated with "towing a low-drag device".



Fish swimming with the float tethered to their dorsal musculature (at the base of their dorsal fin) experience a drag effect more significant than the minimal drag resulting from attaching small acoustic tags to the base of the dorsal fin. Fish fitted with tethered floats also occasionally have the tether (monofilament line) hang on a crab pot float or pier pilings, having to be freed by researchers. In such cases the fish's movement pattern is interrupted, and possibly altered altogether, compared to had its movement not been hindered. If acoustically tagged fish exhibit movement patterns similar to those of fish tracked with tethered floats, the latter data can to some degree be "validated". This is important to accomplish since the tethered float fitted with a GPS provides previously unavailable detail on fish movement patterns and swimming rates over a range of water depths and bottom types.

Introduction

Speckled trout primarily constitute a recreational fishery in Virginia with fishing typically divided into spring and late summer/fall periods. Fish are also available during warmer summer months, but are often more scattered, particularly along the western shores of the Bay. During the spring fishery, dominated by large, pre-spawning female fish, anglers' principal fishing method is bait fishing.

Research on other species in the Bay, i.e., striped bass and summer flounder, indicates that when bait fishing, hooking mortality can be significant for released fish. Experienced anglers indicated gut-hooking was likely a significant concern in the bait fishery, possibly running as high as 30-50 % during spring months, while this was not likely a problem with lure-caught fish. Fishing with J-hooks and fresh peeler crab is the more popular fishing practice in the spring fishery compared to fall months when most anglers typically switch to lures (mirrolures and lead-head jigs).

Studies on striped bass have demonstrated use of circle hooks when bait fishing can reduce gut-hooking rates, and thereby significantly increase survival rates of released fish. Therefore, a main objective of the project was to explore whether similar reductions in release mortality might be achieved with speckled trout. This aspect of the study took on new significance when in 2001 the VSFT, to encourage conservation of mature fish known to spawn in Chesapeake Bay, added to its award program release citations for speckled trout (24 inch minimum length).

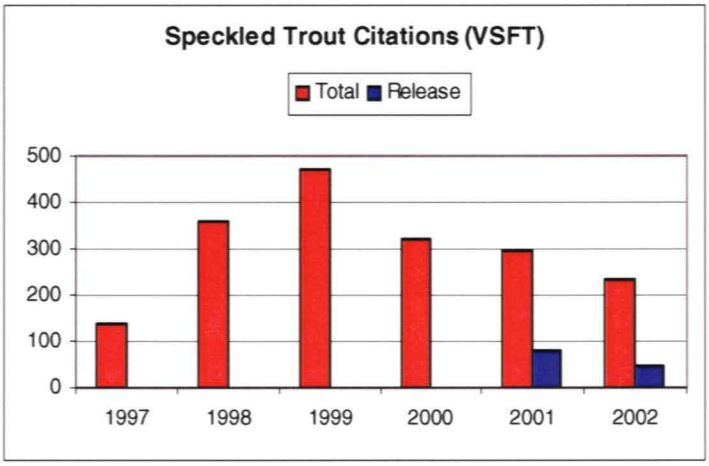


Figure 1. Fluctuations in Virginia's speckled trout fishery 1997-2002.

The study was organized to examine release mortality rates in adult speckled trout (preferably fish 14-15 in /356-381 mm or longer in total length). The main objective was to compare short-term release mortality rates (3 day/72 hour minimum observation period) for fish caught using bait (with J-hooks and circle hooks) and fish caught using artificial lures. The latter would provide release mortality baseline data on the fishery against which to evaluate possible impacts of gut-hooking in the bait fishery.

The project also would explore developing telemetry tracking techniques for trout. If successful, such tracking methods would provide a second means to evaluate short-term release survival rates (24-48 hour swimming behavior and movement patterns) versus restraining post-release fish in holding facilities. Tracking could also provide a means for additional observations on captured fish for 1-2 days beyond the observation periods in holding facilities, If successful, this effort could provide insight into release survival rates over longer periods. At the same time tracking data could provide a tool to examine day-night use patterns of SAV versus non-SAV areas by adult fish. The latter information would compliment other studies examining associations of juvenile speckled trout with SAV.

Fishery Fluctuations Impact Progress

When the project proposal was submitted January 2000 to the VMRC RFAB (and subsequently funded in July 2000), the recreational fishery had been experiencing a significant increase in larger fish. Virginia Saltwater Fishing Tournament (VSFT) citations had been on the increase, going from 139 (1997) to 471 in 1999 (Fig.1), therefore the timing of the study seemed appropriate.

However, in part possibly associated with the very cold winter of 2000, numbers of Virginia citation fish dropped to 319 in 2000, continuing this downward trend (294 and 233 in 2001 and 2002, respectively). In addition, until last summer/fall, relative abundance of smaller fish (10-13 in/254-330 mm), and intermediate size fish (16-22 in/406-559 mm) appeared to be down (compared to 1998-99). But during 2002, anglers generally seemed to think the fishery was beginning a slight rebound. Good numbers of undersized fish (<14 in/356 mm) were taken throughout the lower Bay, and catches of larger fish also seemed somewhat better.

The decline in abundance of trout, in spite of numerous trips and help from experienced, volunteer anglers to normally productive trout fishing areas, produced no significant bait fishing data in 2000. However, some data were obtained on lure-caught fish and progress was made in developing fish tracking methods. A no-cost extension of the project through 2001 and 2002 allowed work to continue. Good results were obtained on release mortality rates in the lure fishery with help of nearly a dozen anglers. Likewise, refinements continued on fish tracking techniques aimed at overcoming difficulties of tracking the easily spooked fish over shallow-water flats.

However, the spring fishery's inconsistency prevented acquiring useable release mortality data for bait-caught fish. In addition, a critical comparison between two different telemetry fish tracking techniques is needed, i.e., to compare movement patterns of fish using low-drag, tethered floats versus fish fitted with acoustic pinger tags. Such a comparison was almost completed during fall 2002, but unforeseen circumstances resulted in escape of the fish fitted with the acoustic tag before the tracking boat (fitted with a receiver and hydrophone) could move within detection range of the fish to initiate active tracking. Such a comparison is needed to validate fish movement patterns observed to date from over 15 tracks of fish fitted with tethered floats.

Winter kills of speckled trout, reported during 2003 in North Carolina, may again reduce fish available in the Virginia fishery this spring and fall. However, recent reports from North Carolina indicate the speckle fishery is fairly good so far this spring. It is hoped that such will be the case in Virginia.

Methods (field gear and logistics)

Using information obtained from local anglers, 3/0 long-shank, J hooks (Eagle Claw) and 3/0-4/0 circle hooks (Eagle Claw 9222and 2004) were used in preliminary bait fishing trials during 2000 (Fig. 2a). Fall fishing trials involved using mirrolures (3 treble hooks) and lead head jigs with 2/0-3/0 hooks and soft plastic tails (Fig. 2b). In late summer-early fall 2000, efforts were also begun to develop telemetry tracking techniques (methods described later).

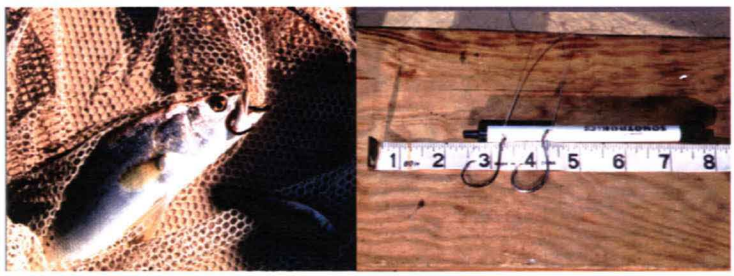


Figure 2a. Unlike J-shaped hooks, non-offset circle hooks can reduce gut-hooking in trout; lighter wire hooks (right photo: 4/0 and 5/0 Eagle Claw 2222 hooks, respectively) likely work better with trout than heavy wire hooks (left photo: 6/0 Eagle Claw No. 9222-snelled).

During fishing trials, basic data were recorded for each fish caught (location of hook wound, degree of tissue damage, bleeding, etc.). A Virginia Game Fish Tagging Program T-Bar tag was placed in the dorsal musculature of each fish and the fish transported by boat in portable live wells to net pens for observation. Salinity and water temperature data were collected during fishing trials and at the nearby holding pens.

To hold fish for observation during mortality trials, portable net pens were constructed by local net makers which could be staked up in protected waters (6-8 ft depths at high water) somewhat removed from boating traffic. Rectangular in shape, made of moderate weight net twine, and weighted at the bottom with a lead-core line, these pens worked well in the Mobjack Bay and Gwynn's Island areas. The net pens were 9.8 ft X 3.3 ft X 6.6 ft deep

Figure 2b. Lead-head jigs (2/0-3/0 hks; varied jig color/soft-tail "grub" combinations) seldom hook trout deeply.

(3m X 1m X 2m) with floats and stakes supporting the 1 in/2.5 cm mesh net. The pen's opening was also coved with netting as well as shading material. Staked up with PVC poles, the net's bottom typically stayed on the sediment surface during rising and falling tides, the preferred position assumed by held fish. The net's floats and open loops of line on the stakes allowed the top of the net to normally stay level with the water's surface (Fig. 3).

Figure 3. Staked net pen with netting/shade cover.

In late summer-fall 2001 good numbers of 10-13 in (254-330 mm) speckled trout congregated in Lynnhaven and Rudee Inlet areas before beginning their fall migration out of the Bay to North Carolina waters. Experimental fishing trials were explored in Lynnhaven but secure and stable locations for mooring net pens were not readily available. After several failed trials to hold captured fish in Lynnhaven, release mortality trials on lure-caught fish were shifted to Rudee Inlet waters. The net pens worked with moderate success in Rudee Inlet during fall 2001, however, overall sample size was decreased when some fish samples were lost due to predation from otters.

As a result vinyl-coated wire mesh cages were used in Rudee during 2002 to hold captured trout. While rectangular cages worked reasonably well (2 ft X 2 ft X 4 ft), a cylindrical cage design (4 ft high X 4 ft in diameter) reduced bruising and associated holding stress in fish (Fig. 4).

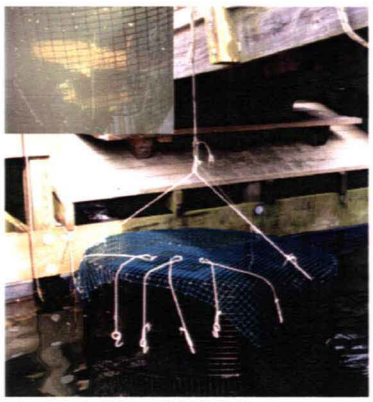
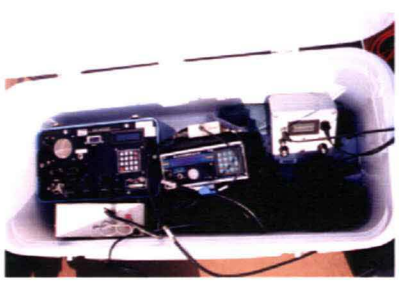


Figure 4. Wire fish holding cage.

In 2002 the spring fishery on 2-5 pound fish showed slight improvement. However, lasting only 2-3 weeks in the Mobjack area (late April-early May), it was not feasible to organize fishing trials producing useful numbers of bait-caught fish. Then inconsistent fall weather made fishing trials unworkable in Mobjack Bay and its rivers. With 10-14 in (254-356 mm) trout again congregating in Rudee Inlet during September-November, release mortality trials were conducted there on lure caught fish. Problems with samples being destroyed by sea otters the previous year were eliminated in 2002 by holding fish in wire cages set on the bottom and secured to docks of cooperating property owners. As in 2001, most fish were released with tags at the conclusion of trials, some being recaptured again by anglers at later dates.

During 2000-2002 substantial progress was made in developing telemetry tracking techniques. Telemetry tracking trials experimented with VEMCO Ltd. 69.0 kHz V8 random coded tags and V8 pinger tags (75 & 78 kHz; 60 pulses/min.) as well as smaller (23 mm long; 8 mm diameter) V8SC pinger tags (72 kHz; 60 pulses/min.) and V8SC coded pinger tags (69 kHz; fixed off time 5 sec). Tags were placed on fish to determine signal consistency and range in the shallow habitat frequented by trout, signals being detected using a VEMCO VR60 receiver with directional and omni-directional hydrophones (Fig. 5a).



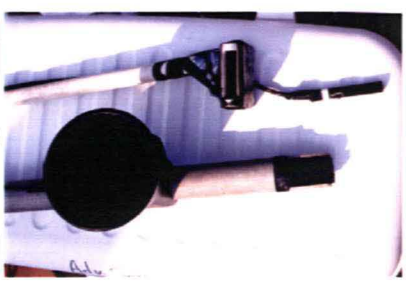


Figure 5a. Acoustic tag tracking receivers for comparing tag signal ranges (VEMCO VR60 on left): directional and omni-directional VEMCO hydrophones paired on PVC pipe (top).

Figure 5b. Tether rigging method; fish kept underwater in livewell and covered with towel during rigging; when released fish may rest 1-5 minutes on bottom, or rapidly swim off towing float with radio tag transmitter (and GPS when using larger float).

Because of inconsistent catches of fish on hook and line, most fish used for tracking trials were obtained from haul seiners (this ensured groups of 3-6 fish being available, sample sizes needed to run multiple trials simultaneously). Compared to haul seine caught fish, hook and line captured fish, especially those used in October 2002 trials, proved to be more active and stronger swimmers when released with tethered floats.

Detection ranges for acoustic tags were often inconsistent, typically being less than 500 ft (152 m) but sometimes as good as 700-1000 ft (213-305 m). Signal loss was in part attributed to water turbidity, but more importantly to subaquatic vegetation (SAV) on the flats frequented by the fish. Given such limited signal detection ranges, a serious concern is whether proximity of the tracking boat to the fish may unknowingly frighten the fish periodically, eliciting an escape response and thereby atypical movement patterns. As a result of these problems, efforts were expanded to develop another method for tracking movements of fish over the flats.

The alternative method used low-drag, spherical plastic floats tethered to fish with monofilament line, the line being gently pushed through the shoulder muscle of the fish just under the dorsal fin using a medium gauge needle. Tether length ranged from approximately 20-30 ft (6.1-9.1 m) to allow fish to move into main channel areas without being subjected to lifting forces from the float. Line was typically 30 lb (13.6 kg) weight monofilament fishing line, the floats containing small GPS instruments Once through the muscle and the dorsal fin's bony fin ray supports, the running end of the line was secured in place with a plastic button (0.4-.05 in/10-13 mm diameter) (Fig. 5b). This prevented the tether from pulling back through the fish's muscle as it swims. A piece of elastic material was incorporated in the tether to reduce surge pulls on fish making sudden runs.

Equally important, the tether attachment process minimized tissue trauma in cases where the tether happened to catch on objects (crab pot floats, pier pilings, etc.), an occasional problem. In such cases, periodic checks on the fish's location allowed the fish to be freed from the obstruction and it swam off. This was possible since during numerous tracking trials, fish's tethered floats were under almost constant observation for lengthy periods. Significant boat distances were maintained from the fish (0.25-0.5 mi) by using binoculars (daylight hours) and a night vision scope (during darkness). The scope permitted locating the float when, besides its transmitter tag, it also contained a battery-powered, 1-second flashing red LED (light-emitting diode).

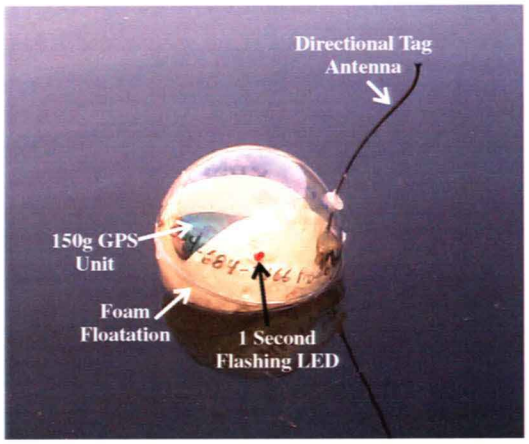
Fish, once placed in portable livewells in the boat, were wrapped in a soft towel and kept mostly submerged while the tether was secured in place. The fish's head and gills were continuously kept under water and covering the

fish's eyes with the towel maintained it in a calm condition while cradled in the researcher's hands. Time from starting the tether placement procedure to releasing the fish was usually no more than 2-3 minutes. When released overboard, fish most often swam slowly away, stopped to rest on the bottom near the boat (1-5 minutes), then began a steady swimming pattern (Fig. 5b). In other instances fish also would swim rapidly away from the boat when released, then slow to a more steady pace of continuous movement.

Initially 312g GPS units were experimented with in styrofoam floats because positions could be saved at fixed intervals (e.g., 1-3 minutes). However, the floats were replaced during 2001 with more streamline plastic spheres and 5.3 oz/150g GARMIN hand-held GPS units. These units have a 1000 position memory and time interval options of 30-300 seconds between saved positions (3 min. interval provides 480 positions per 24 hour period or up to 2 days of tracking memory). Through flume tests at VIMS, at water current speeds of 1-2 kt, drag on the largest float (containing extra batteries and the 5.3 oz GPS unit) was determined to be only 0.5-1.4 oz (15-40 g), the loaded float having only about 30-50 % of its diameter submerged below the water surface.

Figure 6a. Two sizes of plastic floats used in telemetry tracking trials; smaller float (3 in diam.) contains foam floatation and radio transmitter tag with battery; larger float (5.5 in diam.) contains same items plus GPS and one-second flashing LED plus extra batteries.

Two sizes of floats were used in tracking trials (Fig. 6). Smaller diameter floats (3 in/ 76 mm), manufactured in two halves, carried radio transmitter tags (1.9 oz/55 g directional transmitter plus battery-Wildlife Materials, Inc.) along with foam (to ensure floatation in case of water leaks). Sealed closed to keep the battery connections dry, the spheres float upright with the tag's antenna extending through a small drilled hole sealed with hot glue. They could be detected from a boat (using a Wildlife receiver and hand-held antenna) over distances of 3-5 miles. Researchers quietly approached the float periodically to record the fish's position, then drifted away, allowing the fish to continue its swimming activity.



6b. Large plastic tethered float showing radio tag antenna, LED, and GPS.

A larger plastic float (5.5 in/140 mm diameter) enabled combining the radio transmitter tag and batteries with a small, GPS unit such that detailed position data (saved at 1-3 minute intervals) was accumulated in the GPS unit memory for periods of 10-12 hours (Fig. 6b). Battery life was the time limiting element more so than GPS memory capacity. Using the radio telemetry tag signal to periodically check on the fish's location, researchers remained far away from the swimming fish for longer periods. Several times over 24 hours, researchers quietly approached the float to replace the GPS with another unit so the track data could be downloaded to a laptop computer (using Chartview software).

Results

Release Mortality Trials

During 2000 preliminary efforts were initiated during May-June to catch trout on baited hooks (3/0 circle and J-hooks) in the Mobjack Bay area working with volunteer anglers. Insufficient numbers of fish were caught fishing from shore as well as boats in normally productive areas. A preliminary trial involving 13 fish was terminated

when all fish escaped from the net pen when a curious angler tore a large hole in the net with his outboard prop.

Some value was derived from this trial, however the results were mixed between fish caught on circle hooks and those on J-hooks. The fish averaged 18.2 in (462 mm) in length (range = 11.5-21.75 in/292-552 mm). Of nine fish taken on 3/0, long-shank J-hooks (Eagle Claw), three (33 %) were gut hooked, all dying in the boat livewell within 1-3 hrs. Of the overall group, one lip-hooked fish also died in the net holding pen (3 day holding period). Therefore, overall release mortality was 44 % for J-hook caught trout.

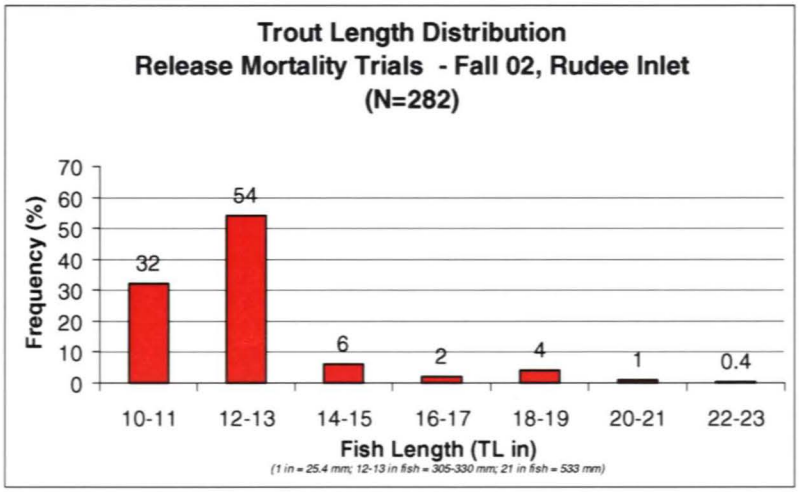


Figure 7. Length distribution of speckled trout captured during release mortality trials- Rudee Inlet, fall 2002.

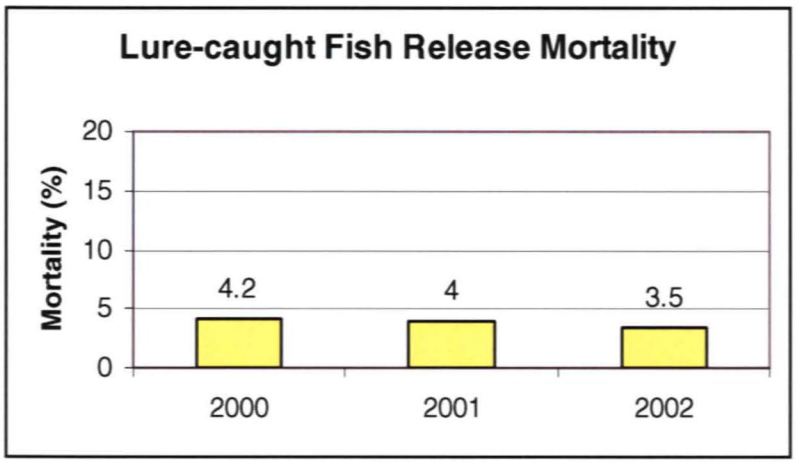


Figure 8. Release mortality rates consistently low for lure-caught fish.

Of four fish caught on circle hooks, two surprisingly were gut-hooked, dying within 1-3 hrs in the boat livewell, a 50 % release mortality rate. Regarding circle hooks, these results indicate that issues such as hook size, hook wire weight, gap distance, and offset/non-offset style need to be examined. Certain circle hooks can result in gut-hooking in given species (and certain sizes of fish). This result has also been observed in undersize red drum during fall 2002 (C. Bain, personal communication) and the winter 2002/03 fishing at the Elizabeth River Hot Ditch (J. Wright, personal communication).

During October 2000 coordinated fishing trials with several local anglers produced release mortality data on lure caught fish caught in two locations, the Ware River (Mobjack Bay) and to the north at Gwynn's Island (the "Hole-in-the Wall"). While only a small sample of fish (N=24), the fall 2000 results were verified again in 2001 and 2002.

Fish length was relatively consistent for each year's trials, averaging 11.8 in (300 mm) to 13.0 in (391 mm). As shown in the length distribution of fish from the fall 2002 Rudee Inlet trials (Fig. 7), most fish were 11-12 in (279-305 mm), but a few larger fish also occurred (up to 22 in/559 mm).

Release mortality was consistently shown to be low in lure-caught fish, being 3.5-4.2 % (Table 1; Fig. 8). These results are relatively similar to lure caught fish in a Louisiana study conducted from 1993-1995. Involving over 1,500 fish held for 3-7 days post release, fish caught on single hook lures exhibited a release mortality of around 9 % while fish caught on treble-hook lures showed only 3 % mortality. In the same study, short-term mortality in bait-caught fish ranged from 17-27 % (Thomas et al. 1995. Conference on Release Mortality in Marine Recreational Fisheries, VA Beach, VA). A Texas study (1991-93) indicated speckled trout not deep-hooked in the gut experienced about 4 % release mortality (48 hour holding period) while gut-hooked fish showed mortalities of 21-35 % (Murphy et al. 1995. N.A. J. Fish. Mange. 15: 748-753). Another Texas study (1990) combining bait

Table 1
Speckled Trout Short-Term Hook Release Mortality Experiments

Fish were caught individually on hook and line by groups of researchers and volunteer anglers using artificial lures (2000-mirrolures with treble hooks; 2001 & 2002-lead head jigs with plastic grubs). Fish were placed in boat live wells, hooking and condition data recorded for each fish, then fish transported to holding areas (2000/01-net pens; 2002-wire cages on bottom). Observation periods averaged 4 days (range: 3-7 days).

Year	Month	Location	Water Temp.	Salinity (ppt)	No. Samples	Fish/ Sample	Total Fish	Mean Length (Range)	No. Died	Overall Release Mortality	Mortality Range Across Samples
2000	October	Ware River	66-68 F (19-0C)	14-17	2	8-16	24	13.0 in/391mm (11.7-22.2 in) (298-565 mm)	1	4.2 %	0-12.5 %
2001	Oct.-Nov.	Rudee Inlet	59-66 F (15-9C)	27-30	6	3-25	75	11.8 in/300mm (10.0-20.0 in) (254-508 mm)	3	4.0 %	0-12.0 %
2002	Oct.-Nov.	Rudee Inlet	44-64 F (7-18C)	18-31	9	12-61	282	12.1 in/307mm (9.0-22.0 in) (229-559 mm)	10	3.5 %	0-9.3 %

and lure caught fish showed trout having a 7.3 % release mortality rate over a three day holding period (Matlock et al. 1993. N. A. J. Fish. Manage. 13: 186-189). Work in Alabama (1994-96) showed trout release mortality to range from 9-16 %, higher rates being for single hooks (artificial lures and live bait) versus fish caught on treble hooks (Duffy, J. 2002. Catch and Release in Marine Recreational Fisheries. Symposium 30. American Fisheries Society, J. Lucy and A. Studholme, eds.).

Telemetry Tracking of Fish

As indicated in the Methods section, field tests with the acoustic tags attached to fish have shown signal reception to be somewhat inconsistent in shoal SAV areas (vegetation can block signals and hard sand bottom can deflect signals). Such limited detection ranges make it difficult not to "spook" the fish when tracking them from a small boat fitted with the VR60 receiver and hydrophone setup.

Movement of fish tracked using the tethered float system show fish exhibiting several different general patterns (Appendix A; Figs. 9-12). Fish, typically tracked over at least one night period (and often 1-2 tide changes), can simply move along the flats, going into/out of small coves and shoreline indentions. They may also move out to the edges of flats, often tending to move upriver while staying in the vicinity of the 6 ft bottom contour. In other instances, fish have exhibited a different pattern, moving offshore when released, ultimately crossing the main river channel before then moving along the flats on the opposite shore. In one instance a tethered fish was actually hooked in the early morning by an angler using peeler crab. The fish had been tracked since late the previous afternoon.

One of the most interesting elements of the tracking work has been to determine the linear distances over which the fish move in relatively shore periods of time. Tracks to date show fish released for periods ranging from 9-61 hr. covering distances of 0.5-6.1 mi (Appendix A). They typically move at speeds over the bottom of 0.1-0.3 kts, occasionally reaching speeds of 0.7 kts or more. Fish also show a tendency to stay in, or move across rivers to areas which historically have proven to be good fishing areas, not a surprising finding to experienced anglers. Speckled trout also are proving to use a range of bottom depths and habitats, i.e., areas with and without SAV as well as shallow to deeper channel areas. The tracking data, once better validated as representing natural movement patterns, will warrant more thorough analysis to quantify such elements.

Conclusions

Short-term (4-7 day) hook-release mortality in lure caught fish is low (3.5-4.2 %); however, more field trials are required for bait caught fish using J-hook and circle hooks. Such trials are important to determine whether terminal tackle options significantly impact release mortality in adult trout.

Adult trout tracked using the tether-float-GPS system move throughout SAV and non-vegetated shallows as well as transit small estuaries up to approximately 1 mi/1.6 km wide in their lower reaches. The GPS unit provides accurate, detailed position tracks; however, field tests must determine whether the tether-float system may be influencing fish movement patterns. Tracking acoustically tagged fish simultaneously with tethered float fish should help better clarify this issue of concern.

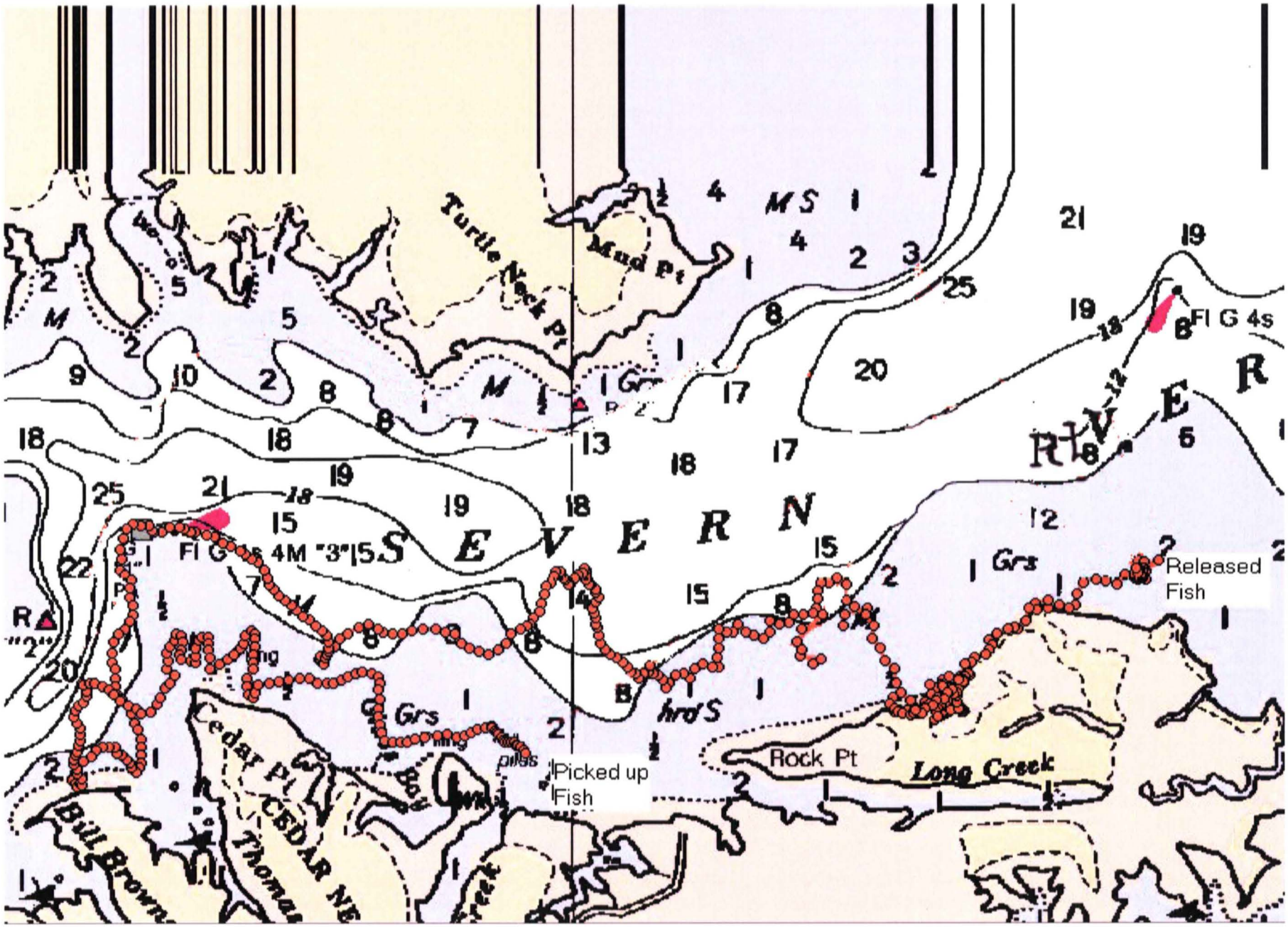


Figure 9. GPS track of trout released September 2000 at mouth of Severn River (Mobjack Bay); tracked 9/9 (1750) until 9/10 (0850), moving about 3.2 mi over 15 hrs.

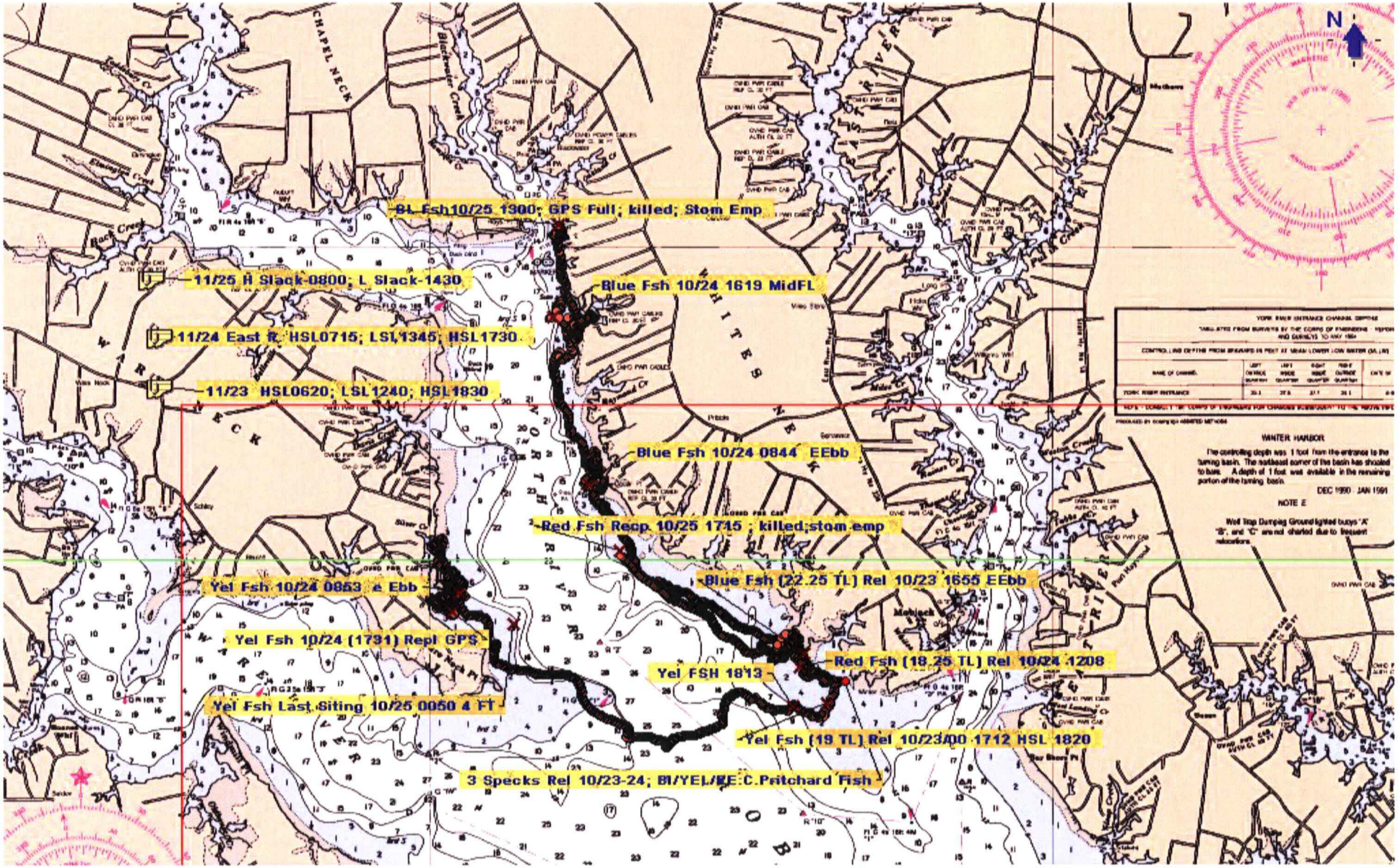


Figure 10. GPS tracks of three trout ("blue, yellow & red" fish) released October 23-25, 2000 at mouth of North River (Mobjack Bay); fish moved about 5.0 mi (48 hrs), 4.8 mi (31 hrs), and 3.6 mi (29 hrs), respectively

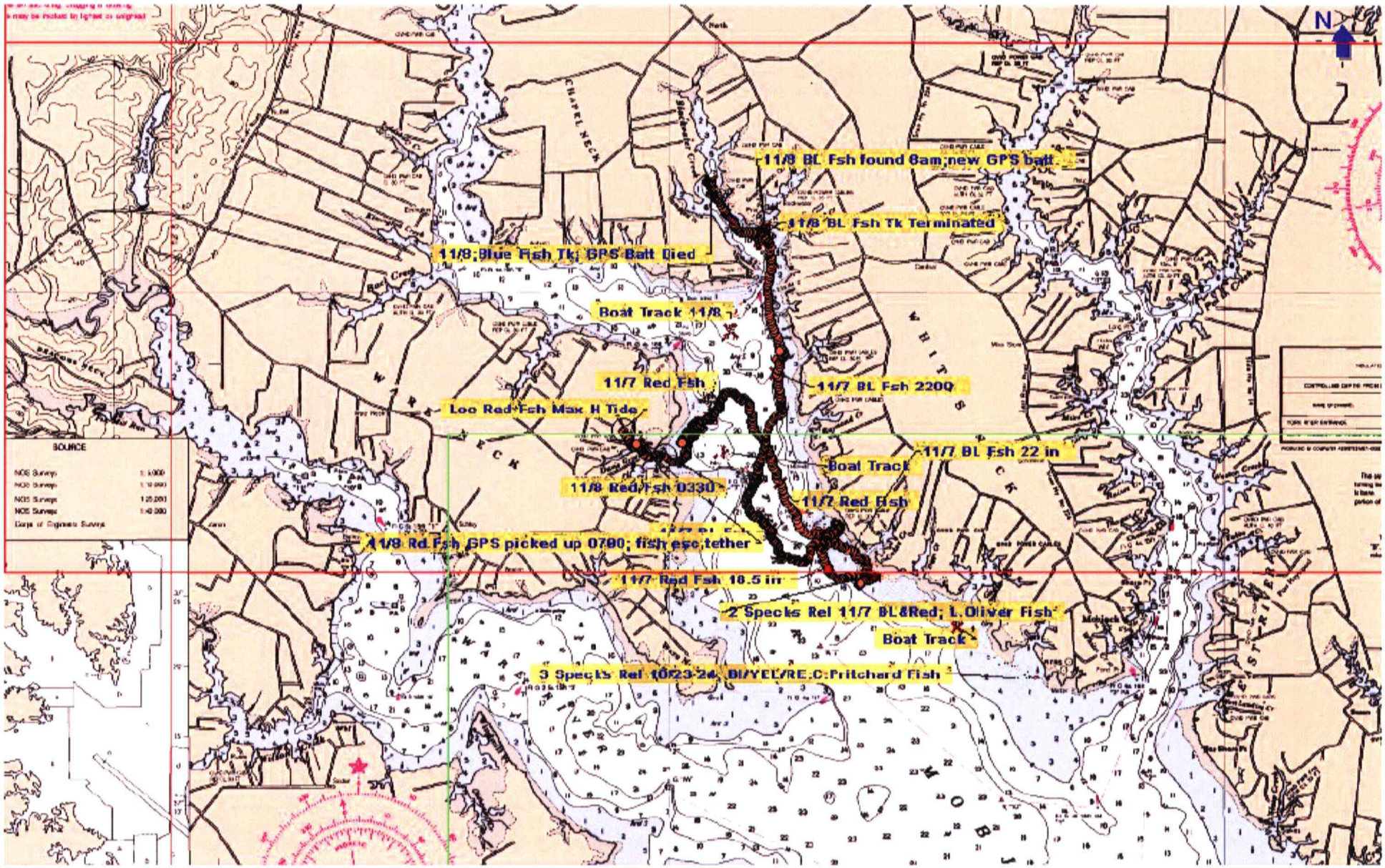


Figure 11. GPS tracks of two trout ("red & blue" fish tracked November 7-8, 2000 at mouth of North River (Mobjack Bay); fish moved about 4.5 mi (18 hrs) and 6.0 mi (21 hrs), respectively

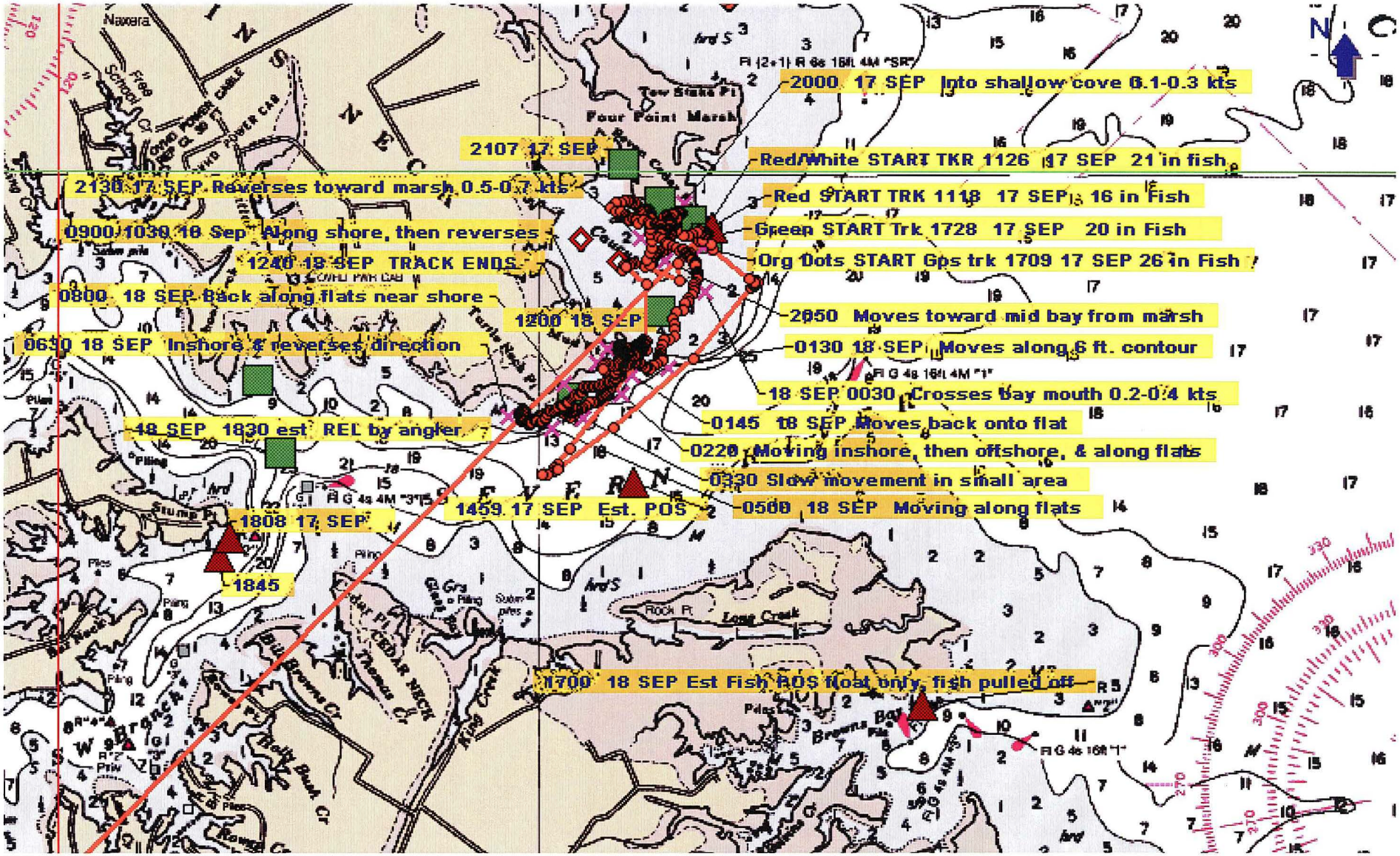


Figure 12. GPS track and visual waypoint "tracks" of four trout released September 17-18, 2002 at Caucus Bay (between mouths of Severn and Ware Rivers off Mobjack Bay); fish moved 0.8 mi (7 hrs), 2.7 mi (25 hrs), 3.6 mi (19 hrs), and 6.1 mi (24-30 hrs): orange lines are boat GPS track, not a fish track.

Appendix

Appendix - Summary of speckled trout tracking results using tethered float methods; GPS track data downloaded from units in floats; visual observations represent manually logged waypoints (WPs) when boat adjacent to float; floats often fitted with light emitting diode (LED) to determine fish-float location during darkness (using night vision scope from boat).

Date	Location	Fish Length (in)	Track Mode	Start / Finish Times	Total Hours	Est. Distance (mi.)	General Movement Pattern & Direction	Depth Temp Salinity
Sept. 2000	Severn River; Mobjack Bay	19	Foam Float w/GPS &LED; Visual WPs	S- 9/9 1750 F-9/10 0542	12	2.3	Rel. at river mouth S. shore, went across river, then upriver along N. shore	Depths:1-17 ft T 70 F Sal.18 ppt
Sept. 2000 Fig. 9	same	27	same & Visual WPs	S-9/9 1750 F-9/10 0850	15	3.2	Rel. at river mouth S. shore, moved upriver along 6 Ft contour, turned back downriver before dawn, picked up 9/10 on flats just off Kings Ck	same
Sept. 2000	same	21	same & VisualWPs	S-9/11 1754 F-9/12 0900	15	2.2	Rel. at river mouth S. shore, moved across river and upriver on N. shore; caught/rel. by angler 0730 with tether/float attached; picked up 0900 and rel.	same
Sept. 2000	same	17	same	S-9/11 1849 F-9/12 1130	16	1.4	Rel at river mouth S. shore, moved across river mouth, observed in Caucus Bay 0730 by angler; picked up still in Caucus Bay 1130	same
Oct. 2000 Fig. 10 "Blue Fish"	North R., Mob. Bay; river mouth along N. shore, Godsey Ck area	22	Foam Float w/ GPS & LED;, Visual WPs	S-10/23 1655 F-10/25 1630	48	5.0	Rel. at river mouth N. shore near Godsey CK, moved upriver along shore, mostly staying on flats and going in/out several small creeks, picked up 10/25 entrance Blackwater Ck	Depths: 2-12 ft T 68 F Sal. 16-19 ppt
Oct. 2000 Fig. 10 "Yellow Fish"	same	19	same; Partial GPS Trk; GPS loss; Visual WPs	S-10/23 1712 F-10/25 0050 last sighting	31	4.8	Rel. at river mouth N. shore, moved immediately offshore and across river mouth during night into & out of Racoon Cove before lost	Depths: 2-25 ft T & Sal. same

Appendix - Summary of speckled trout tracking results using tethered float methods; GPS track data downloaded from units in floats; visual observations represent manually logged waypoints (WPs) when boat adjacent to float; floats often fitted with light emitting diode (LED) to determine fish-float location during darkness (using night vision scope from boat).

Oct. 2000 Fig. 10 "Red Fish"	same	18	Foam Float w/ GPS; Visual WPs	S-10/24 1208 F-10/24 1715	29	3.6	Rel. at river mouth N. shore, moved upriver staying along N. shore on flats	Depths: 2-8 ft
Oct. 2000	same	16	Foam Float w/ LED; Visual WPs	S-10/24 1125 F-10/25 1136	24	3.0	Rel. at river mouth N. shore, moved across river mouth during night, found in Racoon Cove on S. shore next morning	Depths: 2-25 ft
Nov. 2000 Fig. 11 "Red Fish"	North R. mouth along N. shore, Godsey Ck area	18	Foam Float w/ GPS; Visual WPs	S-11/7 1243 F-11/8 0700	18	4.5	Rel. at river mouth S. shore, moved upriver along flats until dusk, moved across and upriver during night, onto S. shore flats, entered Davis Ck, going up to CK end, back down CK, released inside Ck	Depths: 2-21 ft T-60 F Sal. 19 ppt
Nov. 2000 Fig.11 "Blue Fish"	same	22	Foam Float w/ GPS; Visual WPs	S-11/7 1226 F-11/8 0930	21	6.0	Rel. at river mouth S. shore, moved upriver along flats, moved around small area on flats, moved out into mid-channel and across river toward Davis Ck entrance, back across river to S. shore, upriver along flats into Blackwater Ck.	Depths: 2-23 ft T-60 F Sal. 19 ppt
Sept. 2001	Red Barn Cove (E of Godsey Ck)	16	Plastic Float w/GPS & Rad. Tg, Visual WPs	S-9/13 1005 F-9/13 1915	9	0.5	Rel. on flats outside cove, moved inshore toward shoreline, went close to marsh-beach, then moved into cove	Depth: 1-4 ft T 76 F Sal. 23 ppt
Sept. 2002 Fig. 12 "Red Triangle"	Caucus Bay (between mouths of Severn and Ware Rivers, Mobjack Bay)	16	Sm Plastic Float w/ Radio Tag, Visual WPs	S-9/17 1118 F-9/18 1700	24-30	6.1	Rel. N. Pt. at mouth of Caucus Bay, moved to mid-channel Severn R., then upriver above FLG 4s, back down river at night, Radio Tag sig heard 9/18 (1100) across marsh (likely in Brown Bay); float found in Brown Bay (1700), fish had pulled off of tether	Depth: 2-22 ft T 75 F Sal. 26-27 ppt

Appendix - Summary of speckled trout tracking results using tethered float methods; GPS track data downloaded from units in floats; visual observations represent manually logged waypoints (WPs) when boat adjacent to float; floats often fitted with light emitting diode (LED) to determine fish-float location during darkness (using night vision scope from boat).

Sept. 2002 Fig. 12 "Red/White Square"	same	21	Plastic Float, Radio Tag, Visual WPs	S-9/17 1148 F-9/17 1845	7	0.8	Rel. N. Pt. at mouth of Caucus Bay, moved into Cau Bay, stayed along N marsh shoreline, last observed 1845	same
Sept. 2002 Fig. 12 "Orange Dotted Line"	same	26	Plastic Float w/GPS & Radio Tag; GPS Trk	S-9/17 1704 F-9/18 1248	19	3.6	Moved into Caucus Bay, stayed along N. shore, in-out of sm coves, into mid-bay, back to marsh, moved out bay crossing bay mouth to SE, moving along shore at ebbing tide to Turtle Pt., reversed course along shore to S.Pt Cau Bay, picked up at very low tide	same
Sept. 2002 Fig. 12 "Green Square"	same	20	Sm Plastic Float w/ Radio Tag; visual WPs	S-9/17 1728 F-9/18 1830	25	2.7	Rel. N Pt. Cau Bay, moved into bay, deeper into bay dring night, 9/18 (1200) found hung on crab float in bay, rel. but float taken in water, moved out Cau Bay to Turtle Pt., upriver, angler saw float (at "Cat Hole" off FLG4s), rel. fish, float sunk	Same
Oct. 2002	North River, Racoon Cove (S. shore)	22	Lg Plastic Float w/GPS & Radio Tag; Visual WPs	S-10/1 1825 F-10/2 0853	14	1.5	Rel. Racoon Cove, moved toward cove's upriver end, out of cove across shoal, upriver along shore on flats, into cove near Silver Ck entrance, back out into river.	Depth: 2-12 ft T 72 F Sal. 22 ppt
Oct. 2002 Fig. ?	same	22	Lg Plastic Float w/GPS& Radio Tag; Visual WPs; GPS data lost	S-10/3 1456 F-10/6 1800	75	3.6	Moved into Rac. Cove, out into river, upriver along shore; loss Radio tag signal 10/4; recovered hung on dock above Belleview CK on 10-6 about 1800; fish good condition and released.	