SURF SMELT SPAWN TIDAL RANGE PROJECT

SUMMARY REPORT

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INTRODUCTION

The surf smelt, *Hypomesus pretiosus,* is an important beach-spawning marine forage fish in Washington State. It is presently known to spawn over several miles of shoreline in San Juan County, having been first observed to use the beaches of the county by WDFW in 1989 (Penttila 1999), although local residents likely knew of its spawning activity many years prior to that time. The documented spawning beaches of the surf smelt were significantly expanded by several years of survey effort by the Friends of the San Juans (FSJ) in following years (Friends of the San Juans 2004).

The surf smelt is an “obligate” uppermost intertidal spawner, depositing its adhesive eggs on beach surface material in water just a few inches deep at high tide periods (Penttila 2007). As such, it can be thought of as Washington State’s “classified” marine fish species (of socio-economic importance) that most commonly uses the uppermost intertidal zone for its critical spawning habitat. Conservation of this marine forage fish’s critical spawning habitat has been used as a defining tool for the conservation of intact, natural shorelines in Washington State for many years, with species-specific protective regulatory language appearing in the State Growth Management Act, the State Shoreline Management Act, and the WAC Hydraulic Code Rules, along with similar language pertaining to its companion shoreline- spawning forage fish species, the Pacific sand lance (*Ammodytes*) and the Pacific herring (*Clupea*) (Penttila 2007).

With the rising local concern for potential impacts of climate change coupled with sea level rise, the FSJ was granted funding in support of its project: “Threats, Impacts and Solutions: a Pilot Project to Protect Forage Fish Spawning Beaches and Shoreline Properties in Puget Sound”. A part of this funding supported a project to sample surf smelt spawn deposits in a detailed manner to determine more precisely the total tidal-elevation span of incubating spawn deposits, emphasizing the uppermost edges of these deposits. Such data could be applied to the resolution of often-contentious permitting situations on shorelines proposed for armoring, ie. the documentation of the vertical position of uppermost spawning habitat to be protected from “net-loss”. The data could also illustrate more clearly the vulnerability of surf smelt spawn deposits to the necessary “translation” of intertidal shore-forms landward in the face of sea level rise.

This report will summarize the observations of surf smelt spawn deposits in their uppermost intertidal contests at several sites in San Juan County during the May-July period of 2011.

METHODS

The primary objective of this pilot study was to find and sample as many surf smelt spawn deposits on the shores of San Juan County as possible within its time and funding constraints. The distribution of field effort in the search for spawn was to be based on the already-documented distribution of surf smelt spawning beaches mapped during prior WDFW and FSJ habitat surveys. The hunt for suitable sampling sites would also be constrained by the lack of equipment for boat-based field work, and the need for permission to be acquired from local shoreline landowners to access certain priority spawning sites. It was also determined that spawn searches would be distributed as far and wide across San Juan County as practical (upon state-ferry-served islands).

It was determined that a "suitable" surf smelt spawn deposit site would be on a natural shoreline without discernable impacts from shoreline armoring structures, with an intact extreme high waterline (EHW) zone. A suitable sampling site would have a deposit of surf smelt eggs visually-apparent on the beach surface material somewhere within the species' typical upper intertidal spawning zone. It was felt that there was insufficient time to satisfy the objectives of the pilot study by random sampling of beaches empty of smelt spawn.

The pilot study' field sampling would depart from the customary exploratory smelt spawning habitat survey protocols employed for forage fish spawning habitat mapping (Moulton and Penttila 2001, rev, 2006). The pilot study's sampling protocol would instead consist of the collection of a set of small (roughly 400 gram) samples of beach surface sediment from intervals along a taped transect perpendicular to the shoreline, positioned from above MHHW down through a visible surf smelt spawn deposit to +4.0' in tidal elevation, generally judged by grain-size composition to be below the lower edge of typical surf smelt spawning substrate.

Generally, six samples would be collected along a site transect: at the upper extremity of estimated potential surf smelt spawning substrate at a site (generally between +8.5 and +9' in tidal elevation, then at +8.0', +7.0', +6.0', +5.0" and +4.0' in tidal elevation.

Tidal elevations were estimated from the visible position of the previous high-tide flotsam windrow or wetted line on the beach and the beach slope. The tidal elevation of the last high tide line windrow was determined by the tide elevation data provided for the Friday Harbor tide station, which included not only predicted tidal elevations over time prior to the survey but also observed tidal elevations over time, taking into account transient barometric effects on water levels (at: tidesandcurrents.noaa.gov).

Beach slopes were determined by positioning of a clinometer on a meter-stick positioned up-down-slope at about +7.0' in tidal elevation. During the period of the pilot study, last-high-tide lines were generally positioned around +8.0 feet in tidal elevation. Once the +8.0' elevation was estimated, the positions of the additional sample sites at one-foot vertical drops down-beach along the tape could be estimated by: distance down-tape for 1 vertical foot drop = 1 foot divided by the sine of the beach-slope angle. The shorter lateral and vertical distances up-beach from the last high tide line or +8.0' line to the upper edge of potential smelt spawning/ incubation substrate were then estimated.

Each potentially-egg-bearing sample along the transect was comprised of a few hundred grams of the surface inch of beach material scooped into a wide-mouth plastic jar, labeled with: date, site, transect number and sample number, and preserved in Stockard's Solution, a 5% aqueous solution each of formaldehyde, glacial acetic acid and glycerol commonly used for preservation of forage fish eggs by WDFW and other trained survey groups in the region.

A transect's site data also included a hand-held GPS (Garmin GPS 72H) lat-lon reading at the +7.0' position, charting of the transect location on a 7.5' USGS topo map, and each sample positions' relative degree of shading from WDFW protocols (Moulton and Penttila 2001, rev. 2006). Digital photographs were taken of each transect, with its sample sites marked in-place, from each side and directly up-beach from a down-beach position.

Immediately following each field-sampling day, a written field report was prepared with all relevant observations, charts, tide data, and field data forms pertinent to the survey, to be forwarded to FSJ for the project files.

The potentially-egg-bearing substrate samples were lab-processed following WDFW forage fish survey protocols for "scoop-samples" of field-visible spawn deposits (Moulton and Penttila 2001, rev. 2006). Generally 100-150 grams of material from the sample jars was arranged around the outside edge of a large Petri dish. After immersion in water, this material was carefully inspected with forceps at 10X from one end of the deposit to the other. Any encountered surf smelt eggs were counted as they were aged into a set of 8 embryological-stage categories, plus dead eggs, on a multi-place mechanical counter. After the visual inspection, the inspected material was blotted and then wet-weighed on a digital scale to .1 grams.

RESULTS

A total of eight field-sampling days were undertaken for this project between May 11 and July 7, 2011. Surveys of documented surf smelt spawning sites on Lopez Island on May 24 and June 21, and Orcas Island 20 were unsuccessful in locating surf smelt spawn deposits suitable for the purposes of the project.

Data were gathered from eleven sample transects during the course of the field surveys, detailed on Table 1. Six sample transects were found in two sectors of the shore of Blind Bay, Shaw Island, while the shores of Bell Point, Westcott Bay (within the English Camp National Historical Park), San Juan Island yielded five sample transects.

Surf smelt eggs were found throughout the tidal elevation range sampled (Tables 2 and 3). The majority of the eggs were found at +7' and +8' in tidal elevation. The distribution of surf smelt eggs within the upper intertidal zone was highly variable, reflecting variations in substrate character/"attractiveness", and the timing of spawning events with relation to the tidal elevation of the water line at the time.

All this project's spawn-sampling transects were collected in a "very protected" exposure context, and it was unlikely that the distribution of smelt eggs was altered significantly by wave action following deposition across the tidal elevation range sampled.

Of particular interest was the fact that nearly 5% of the total eggs were found at the highest potential substrates sampled, in sites #3 and #9, on the west shore of Blind Bay, Shaw Island. Estimated tidal elevations of these highest samples were +9.0' and +8.7' respectively.

DISCUSSION

The characteristics of the particular microhabitat context of the highest samples on the particular transects in western Blind Bay may hold a key to usage of these uppermost intertidal sites by spawning surf smelt. These sample sites were within about 50 feet of each other, under the same large overhanging/shading willow tree complex and undercut upland bank, affording about as complete a shading effect as might ever be expected along a Puget Sound shoreline. The two transects were sampled about a month apart in time, with the early June eggs already nearly "middle-aged" in embryological stage, while the early July eggs were "young". Given the approximately two-week incubation time of surf smelt eggs in the summer months, it can thus be assumed that the two transects sampled the spawn deposition of wholly-different spawning episodes, despite their physical proximity.

The uppermost beach substrate sampled on these two transects was the "sandiest" material sampled at the upper/landward-most ends of any of the 11 transects sampled for the project. This sediment texture may have promoted both the attraction of ripe fish to this very high elevation and the survival of deposited eggs by the retention of capillary moisture during low tide period, abetted by an almost completely shaded context. These highest eggs were incubating in a relatively healthy condition, with an in-situ mortality rate of only 10%, while the mortality rate for all eggs encountered on all transects and elevations was 60%. This overall mortality figure was still relatively low for summer-spawned surf smelt egg deposits, reflecting the partial shading effects found at many of the project's other transect sites. Typically, sun-exposed surf smelt spawn deposits in the summer months commonly experience in-situ mortality rates approaching 100% (Penttila 2002, Rice 2006).

The lack of surf smelt eggs at the highest elevations of the project's other transects may reflect the relatively low attractiveness of their uppermost substrates to the ripened fish. At many of the other transect sites, the uppermost beach substrates available for sampling at the appropriate tidal elevations, however natural, were characterized by coarse gravel, mollusk shell fragments, and varying amounts of coarse organic matter derived from the litter-fall from the adjacent upland forests. As such, this material lacked the finer grained sediments that commonly characterize surf smelt spawning substrates found on Puget Sound beaches (Penttila 2007). While the project's transects sampled outwardly natural unarmored shorelines, similar coarse sediments are also un-naturally generated by bulkheads intruding into the intertidal zone during shoreline development, due to increased turbulence and the sorting of finer sediments away from the toes of the structures (Johannessen and MacLennan 2007).

The relative lack of surf smelt eggs at the highest elevations of many of the project's transects may also simply reflect the relatively low proportion of time during a typical daily and monthly tidal cycle that the highest bands of potential spawning substrate are physically available to the ripened fish. The mean higher high water (MHHW) line at the Friday Harbor station is about +7.8'. Note that 28.2% of the total number of eggs encountered on the project's transects were found at +8.0' in elevation (Table 3). Still higher elevations are visited even more seldom by the few-inch-deep waters used by spawning surf smelt, but they were still demonstrably being used successfully by spawning smelt in at last 2 out of 11 instances tested.

CONCLUSIONS

This pilot project sampled the uppermost intertidal limits of potential surf smelt spawning habitat and spawning activity to a greater degree than any previous surf smelt studies in Puget Sound known to the author. The critical habitat value of natural beach substrates significantly higher in tidal elevation than local MHHW was clearly demonstrated. In endeavoring to protect all documented forage fish spawning habitats from "net losses" due to human shoreline development practices, uppermost intertidal sandy substrates on documented surf smelt spawning beaches should be protected from such practices during the course of permitting decisions.

It appears that any intrusions below extreme high water (EHW) lines on documented surf smelt spawning beaches on existing natural shorelines should not be permitted. Any unavoidable impacts due to intrusive new armoring or interruption of natural erosional sediment inputs must be mitigated-for.

Until such time that all shores are adequately surveyed for the documentable distribution of surf smelt spawning habitats, all fine-grained shorelines that include sandy uppermost tidal elevations should have those uppermost zones included within the areal extent of their “potential” spawning habitats, subject to appropriate pre-project resource survey activities during the consideration of permitting of shoreline development, and have protective conservation measures applied to these uppermost elevations.

When considering the restoration of degraded known or potential surf smelt spawning beaches, consideration should be given within the restoration design for the establishment and maintenance of sandy substrates in the uppermost intertidal elevation zones of a project, as well as at lower elevations in the spawning zone, if wave action regime, shoreline aspect, and sediment sources, both natural and augmented, allow such fine-grained zones to be naturally established.

From its position at the very uppermost intertidal zone fringe on protected Puget Sound beaches, surf smelt spawning habitat quality will represent the “tip of the [habitat conservation] spear” as the predicted sea-level-rise attempts to “translate” shorelines landward over coming decades. Proliferating shoreline armoring will both prevent such translation, resulting in a narrowing of habitat zones (“coastal squeeze”) and will exacerbate the coarsening of upper intertidal sediment grain-sizes by wave reflectance off the armoring structures (Johannessen and MacLennan (2007), acting in concert to degrade forage fish spawning habitats very early in the process.

Surf smelt spawn sampling for this pilot project was not exhaustive. A more complete picture of the relationships between surf smelt egg deposition/incubation, tidal elevation and habitat context would be gained by sampling transects at other times of year, in other wave action regimes, and in additional spawning areas within the Salish Sea region.

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