

# **BEHAVIOR OF ANADROMOUS BULL TROUT IN THE PUGET SOUND AND PACIFIC COAST OF WASHINGTON**

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# Abstract

**Bull trout (*Salvelinus confluentus*) are one of only three federally listed fish species that are found in the estuarine and marine waters of Puget Sound and the Pacific Coast of Washington. Until 1980, bull trout were considered the inland version of Dolly Varden (*S. malma*), and largely unrecognized as an anadromous salmonid. In the Puget Sound and Pacific Coast, recent studies have shown bull trout are anadromous, inhabiting estuarine and nearshore marine waters for up to 5 months each year, possibly returning to these waters every year for up to 10 years. Bull trout are recognized as an apex predator in river and estuarine waters and can show a wide array of behaviors in their search for available prey, which can include juvenile salmon and forage fish such as surf smelt, sand lance and herring. We will present results from the first year and a half of a multiyear study investigating the behavior of bull trout in estuarine and nearshore marine waters of western Washington.**



# Introduction

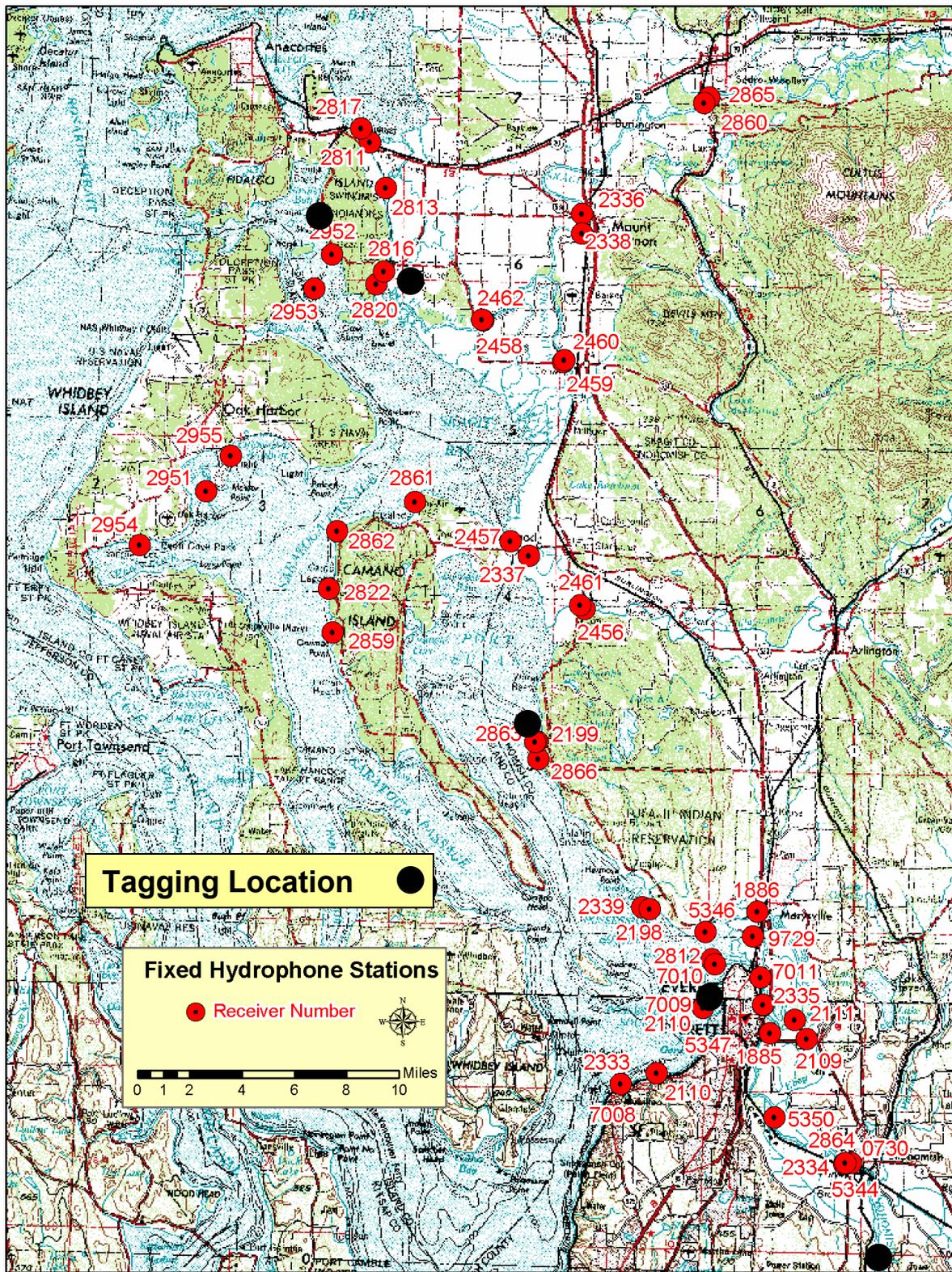
- **As a group, fishes of the genus *Salvelinus* (char) do not make extensive migrations from freshwater into marine waters. Arctic char (*S. alpinus*), a sister species to bull trout, have been described as the least anadromous salmonid.**
- **Bull trout are found throughout the Pacific Northwest of the United States (Oregon, Washington, Idaho, and Montana) and northward to the Peace River in northern Canada. In the U.S. they are listed throughout their range as a threatened species under the Endangered Species Act.**
- **In freshwater, bull trout can undertake complex migrations moving between river basins and traveling over 200 kilometers. Conservation of the migratory life history types is considered essential for the recovery of depressed populations.**
- **Bull trout behavior (distribution, movement, habitat use) has not been previously studied in estuarine and nearshore marine waters.**
- **Our question for this study was - When, where, and why are bull trout anadromous in Puget Sound?**

# Objectives

- **Our Objectives for this study are to identify:**
  - 1. The spatial and temporal distribution of bull trout in estuarine and nearshore marine waters of Puget Sound.**
  - 2. Movement and habitat use patterns – daily, seasonal, and annual – in northeast Puget Sound.**
  - 3. Factors explaining the distribution, movement and habitat use; and**
  - 4. Develop a conceptual model of bull trout life history types in nearshore and estuary areas.**
- **We will present preliminary results from the first 18 months of a multiyear study.**

# Methods

- We are conducting a literature review to identify available information on the spatial and temporal distribution of bull trout.
- We are using acoustic telemetry to track movements and habitat use of individual bull trout in lower river, estuary, and nearshore marine waters. Ultrasonic transmitters (acoustic tags – 54/69 kHz frequency) were used because, unlike radio transmitters, the signal they emit is unaffected by waters with high conductivity (saltwater).
- We tagged fish between March and June of 2002 and 2003. Our tagging locations included the ecotone between freshwater and tidal influence, the edge of major river deltas and Puget Sound, and marine shoreline areas (Figure 1).
- We captured 163 fish by hook and line and beach seine and tagged 119 with acoustic tags. Using surgical incision, we tagged two groups of bull trout – 74 sub-adults (250-400 mm length) and 45 adults (>400 mm). The sub-adult tags lasted 6 months to 3 years and adult tags lasted 13 months to 3 years (Figure 2).
- We used fixed receiving stations (receiver and hydrophone) and mobile surveys (boat) to track the movements of fish (Figures 1 and 2). We recorded habitat information – depth, shoreline type, salinity, temperature, and dissolved oxygen.
- We also collected 92 fish for future stomach content analysis of prey items.



**Figure 1. Fixed receiver stations (total of 59 locations) and tagging locations (5) in northeast Puget Sound: 250 km of shoreline monitored.**



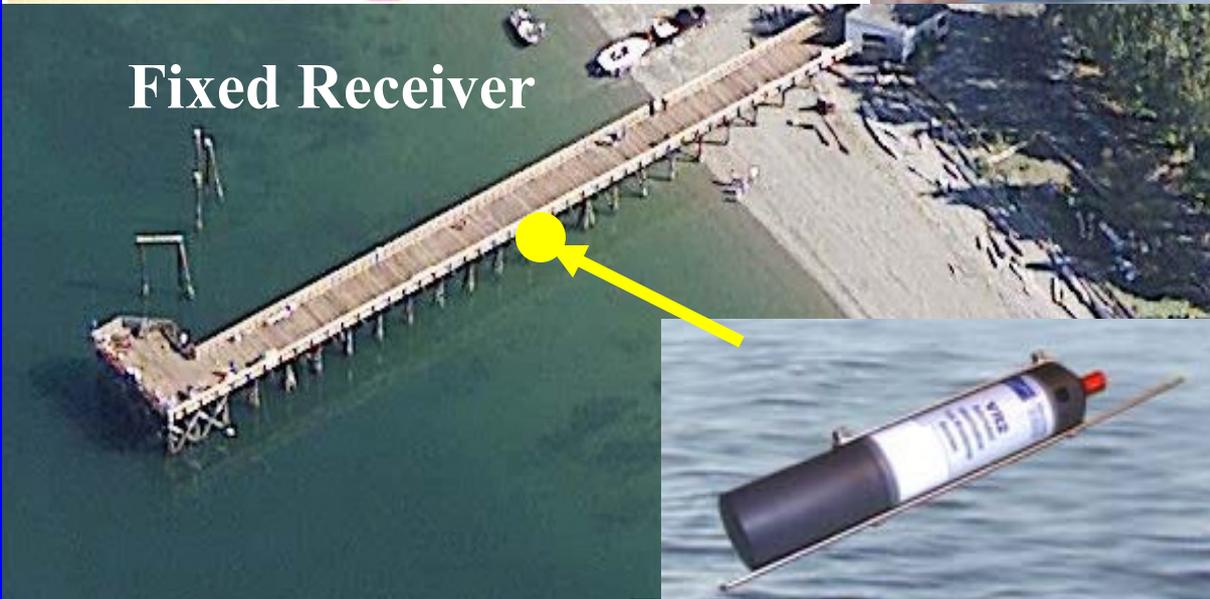
Sub-Adult Tag



Adult Tag



Fixed Receiver



**HYDROPHONE**

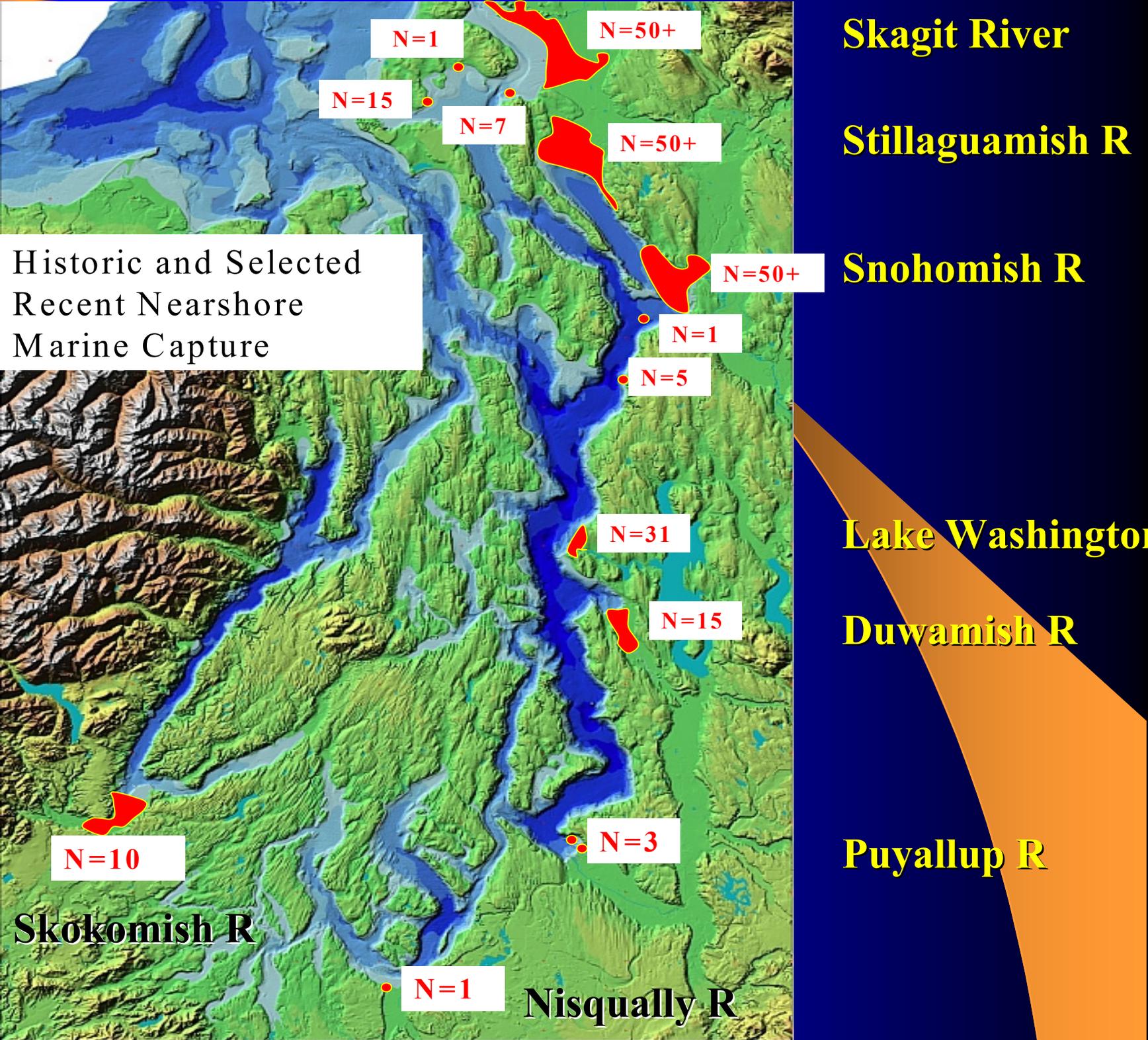
Mobile Receiver



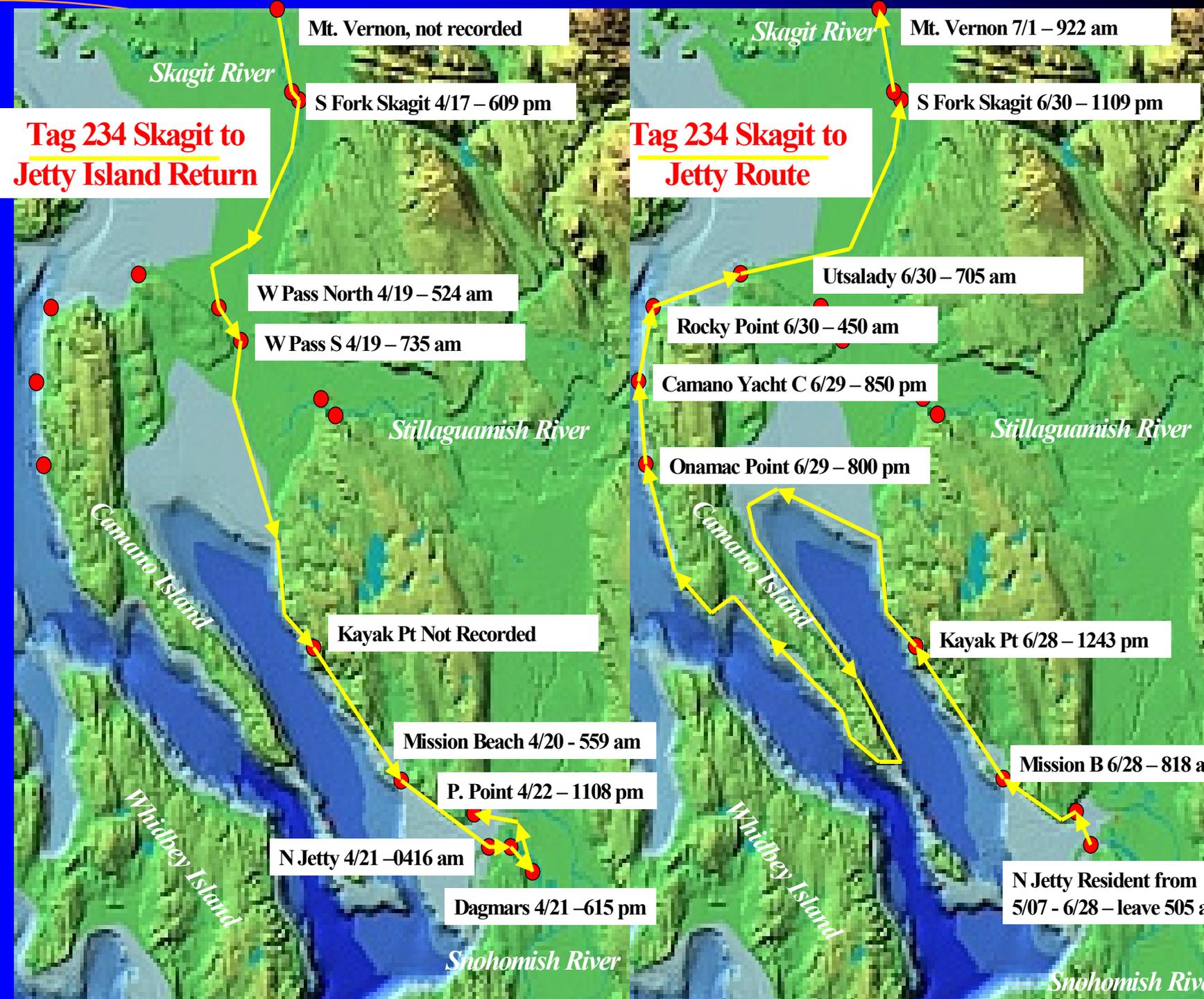
**Figure 2. Bull trout implanted with an acoustic tags, fixed receiver location in nearshore, hydrophone&mobile receiver.**

# Results

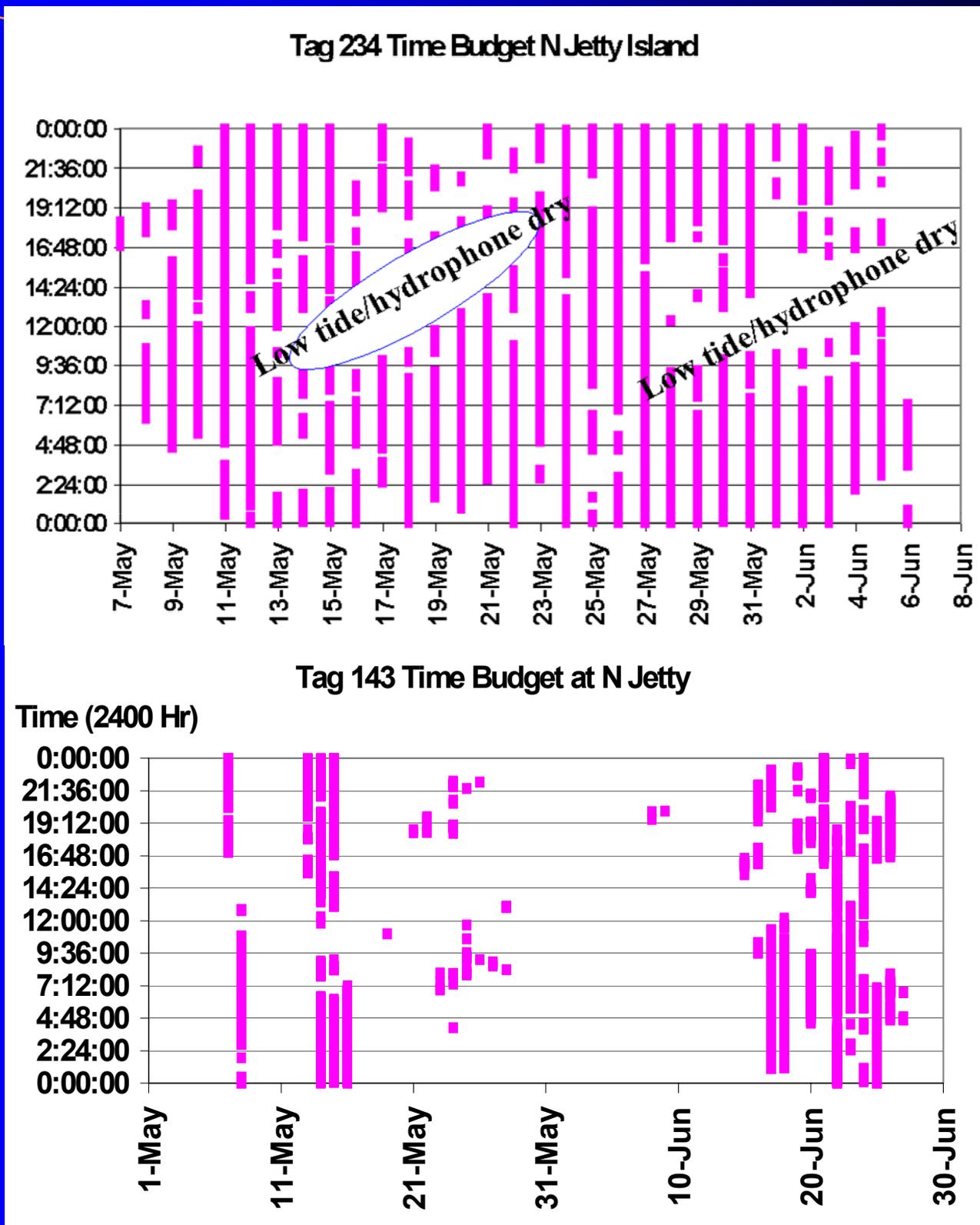
- **A review of available literature indicates bull trout have mostly been captured in or near major estuaries (Figure 3 – this mapping is subjective and must be refined). In time, fish have been predominantly captured (98-99%) between March-July.**
- **Bull trout undertake rapid, directed migrations that may exceed 250 km, using nearshore marine shorelines as pathways. They may switch pathways on return migrations. Figure 4 shows a fish using two different pathways, one 60 km in length the other 120 km.**
- **Individual fish can show fidelity to one site or may move between several areas while foraging for food. Figure 5 illustrates both strategies, the top shows continuous occupation, bottom shows intermittent use of one site.**
- **Site fidelity was shown for our tagging groups both annually and within season (Figure 6). Of fish tagged in spring 2002, approximately 20% returned to the same site the next year whether freshwater or marine. There was higher site fidelity within a season with a range from 30-70%.**
- **Fish show differences in shoreline use by time of day. Char in general are known as crepuscular predators, being active at twilight periods (dawn and dusk). Bull trout occupy shallower depths at twilight and night and are more active at twilight (Figure 7).**



**Figure 3. A literature review of spatial distribution in Puget Sound (N=number captured or minimum estimate, red shading - area of reported use or capture location).**

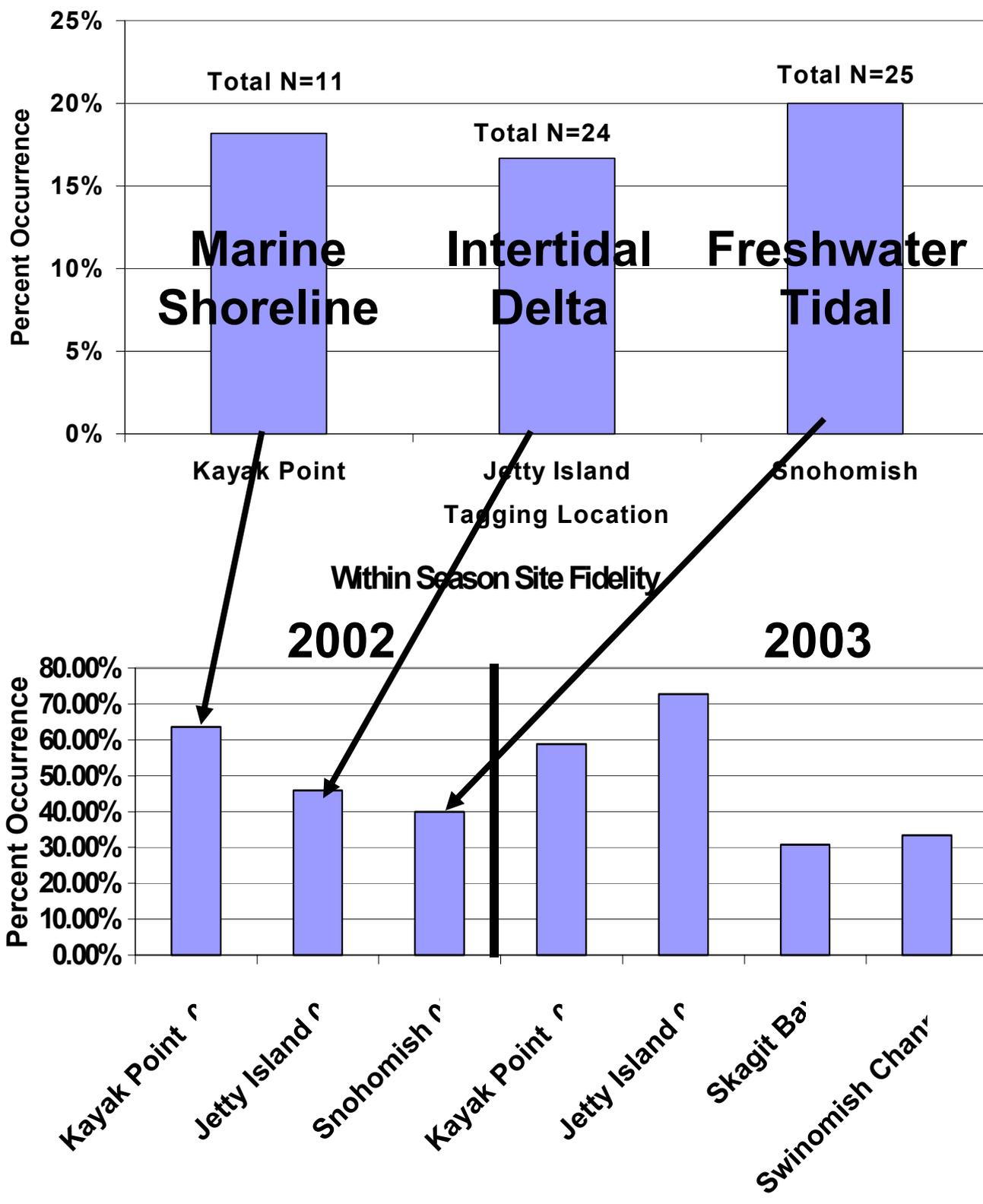


**Figure 4. Migration path of one individual fish (Tag 234), migration from the Skagit R to nearshore marine territory at mouth of the Snohomish (left panel) and return migration to Skagit for over summer habitat/spawning (right panel).**

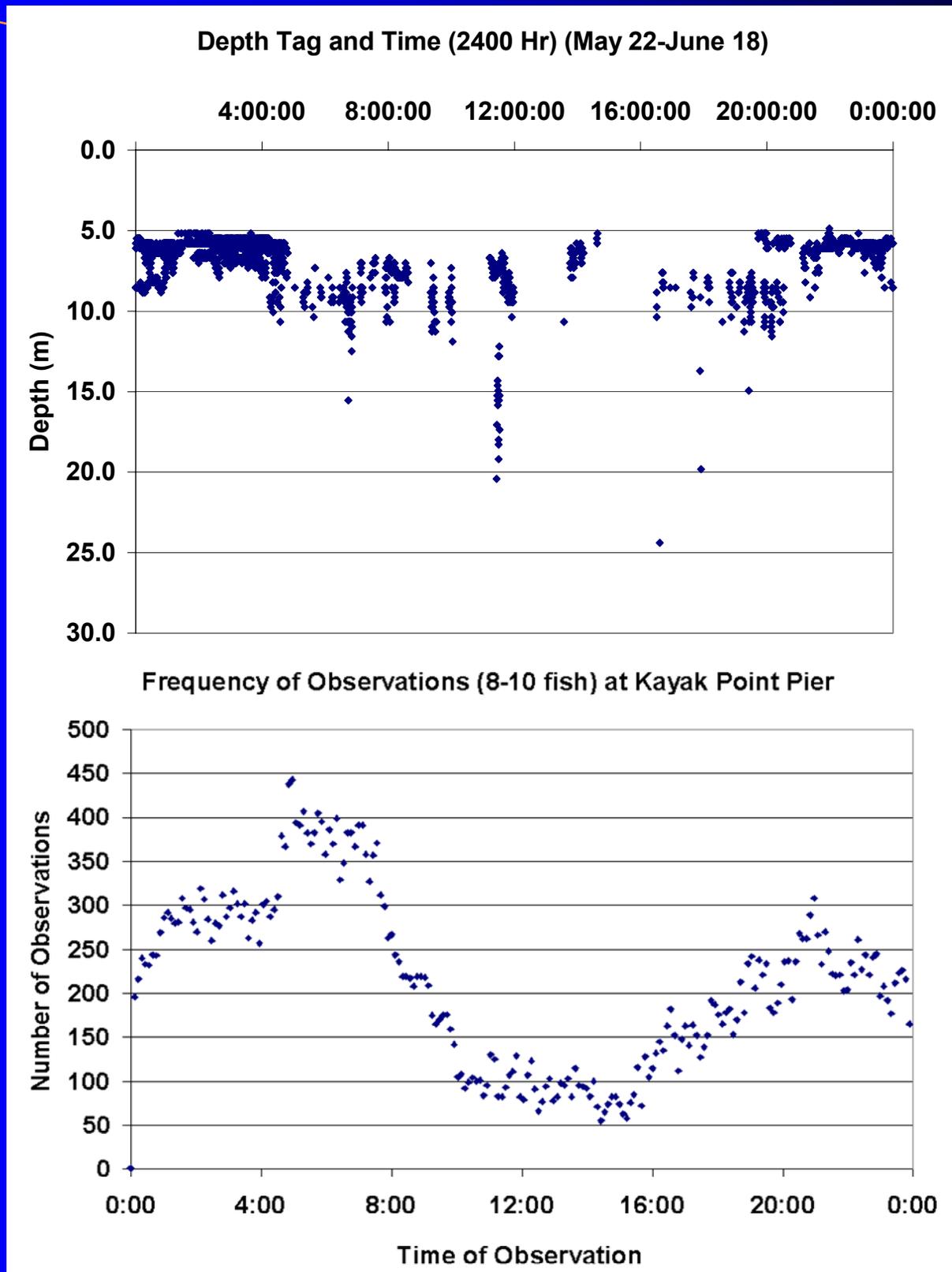


**Figure 5. Time budget for two fish (Tag 234, Tag 143) at one site on the river delta of the Snohomish River. Tag 234 shows a fish occupying the site continuously (migration is shown in Fig 4). Tag 143 shows a fish at the site for shorter intervals.**

## Overwinter Site Fidelity



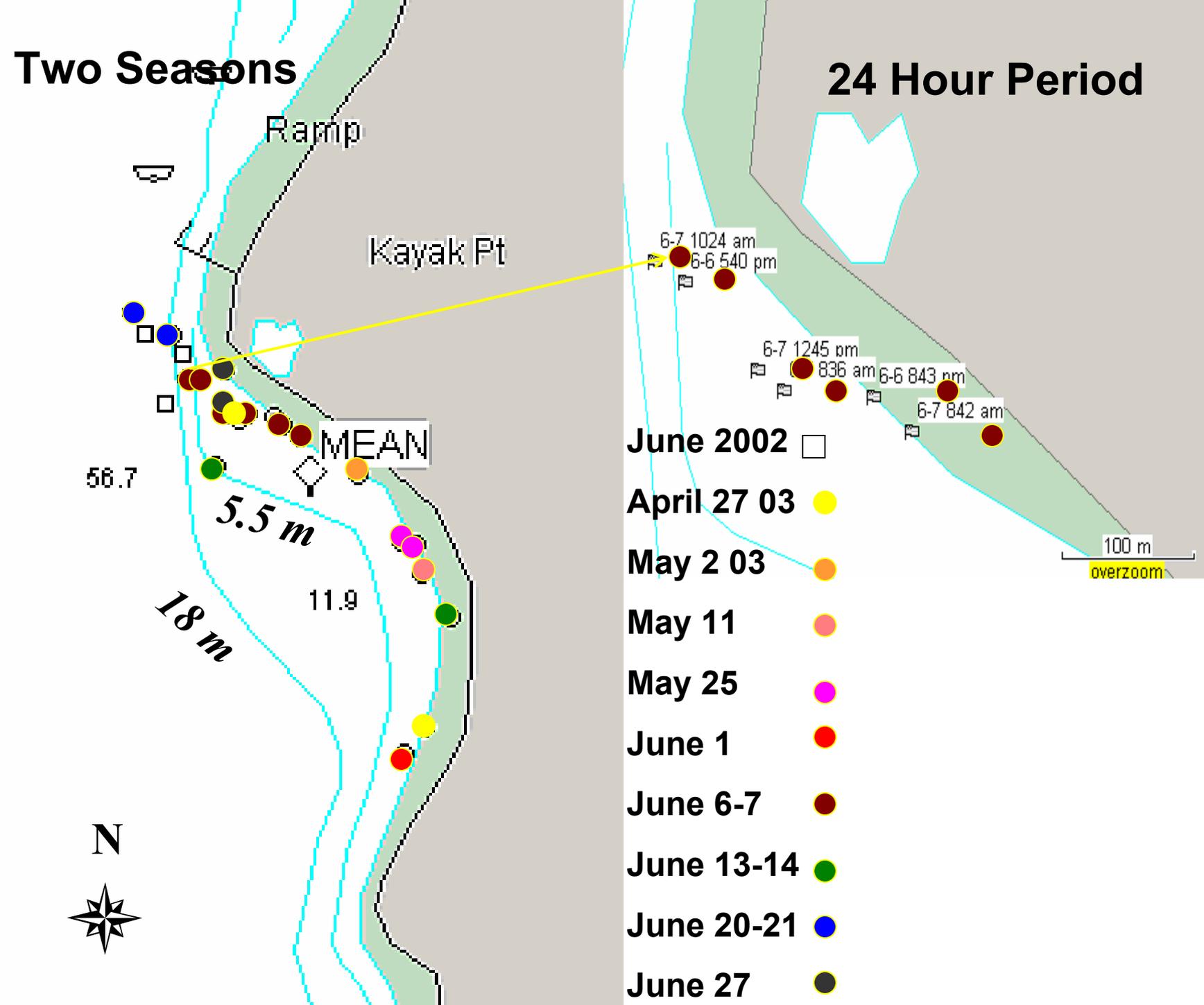
**Figure 6. Site fidelity where fish tagged in 2002 returned to the same site (top) and within season site fidelity (2002/3, bottom).**



**Figure 7. Activity over 24 hours for one and multiple fish at one nearshore marine area. Top figure shows depths for a large female (Tag 6) over one month. Bottom figure shows total detections overtime for 8-10 fish.**

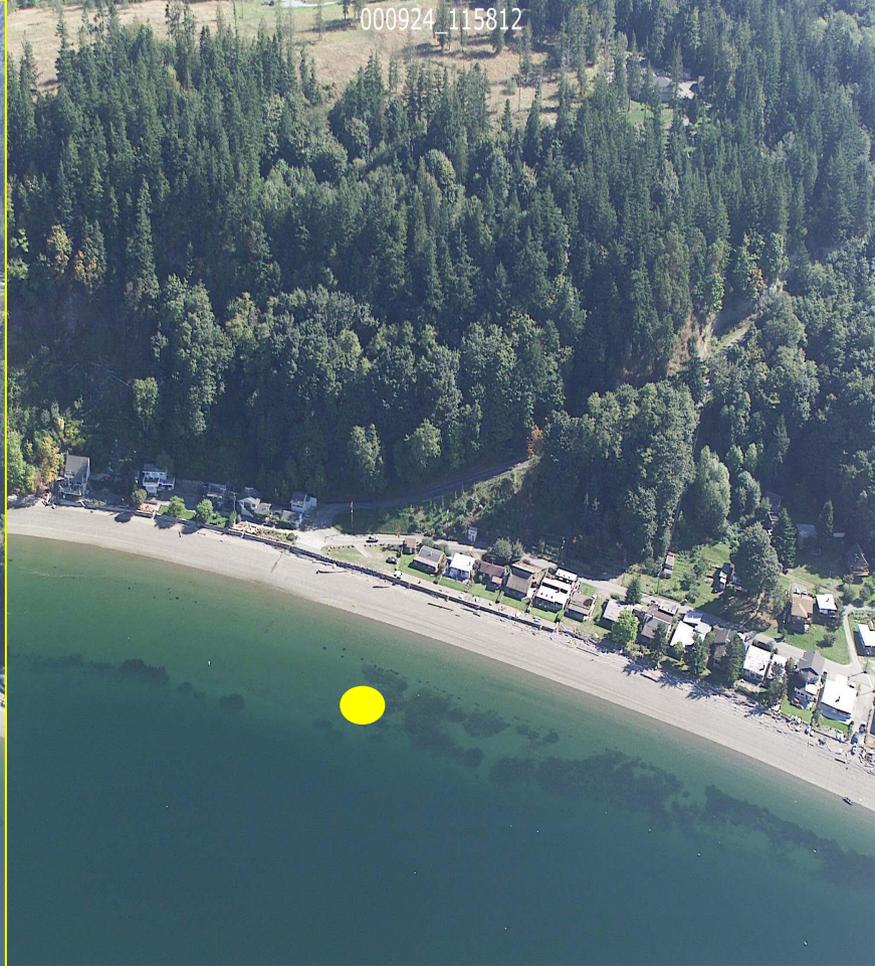
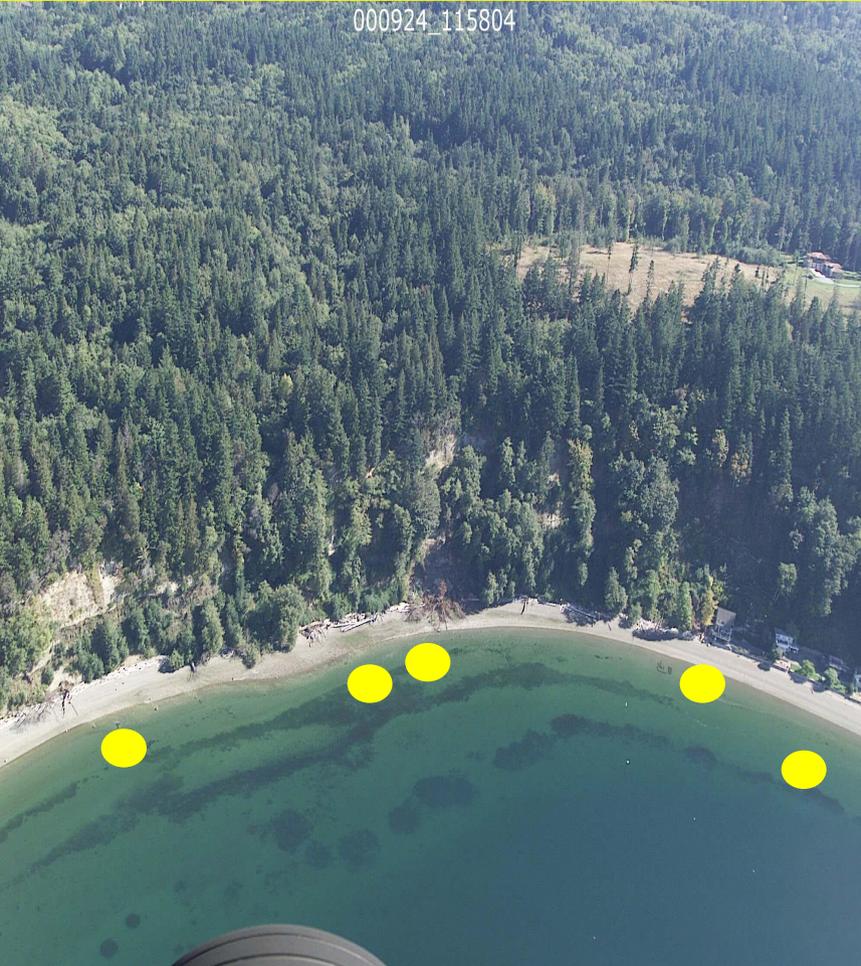
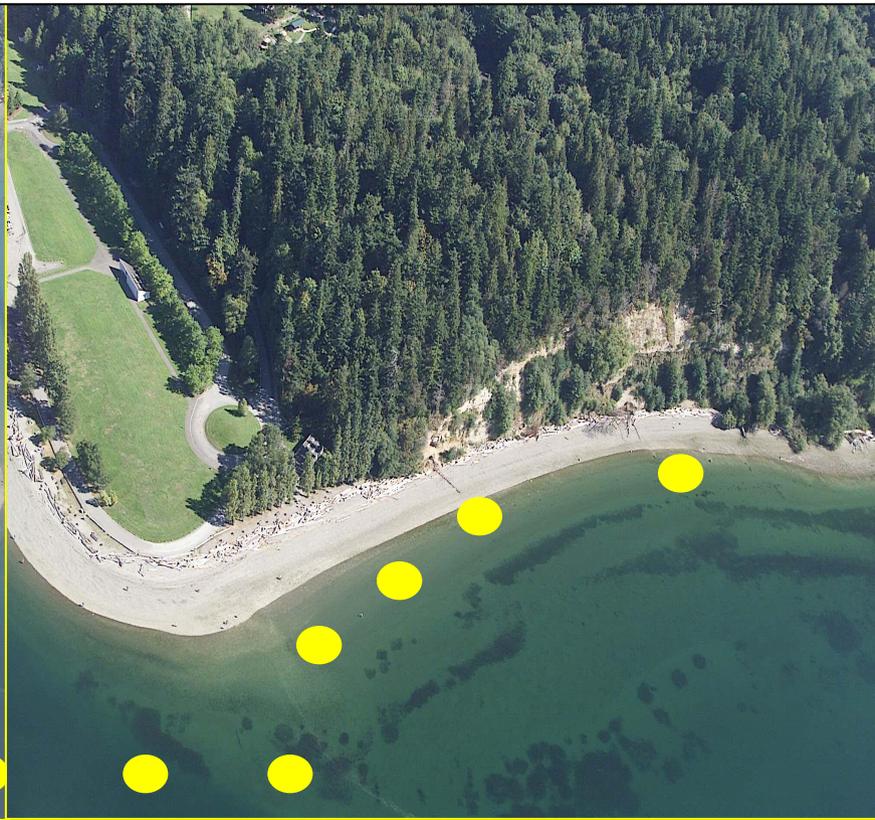
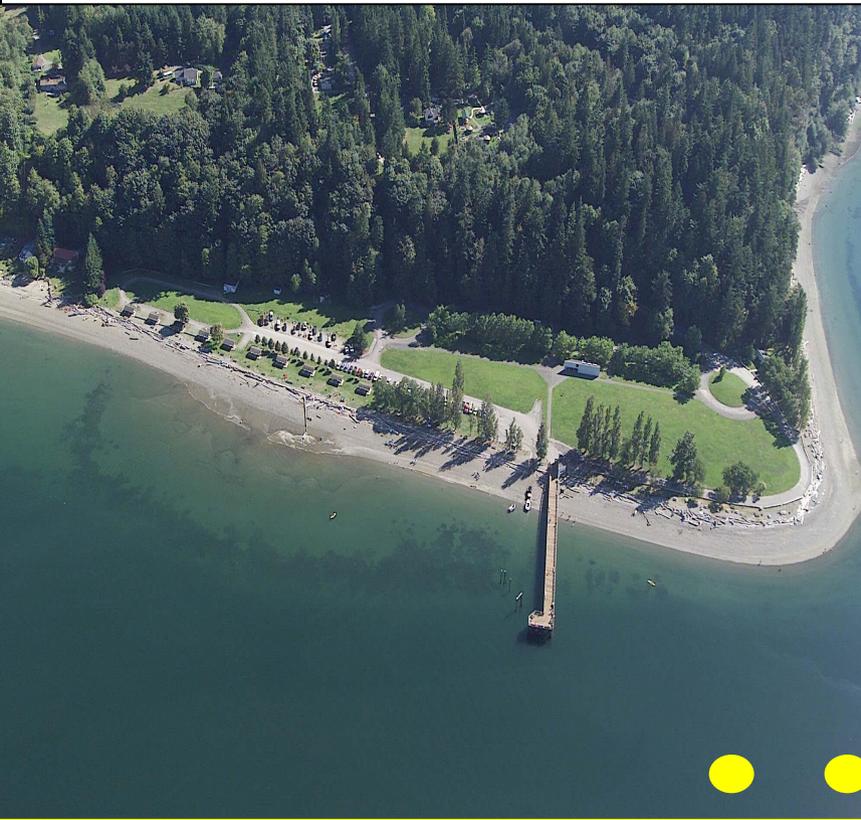
# Results

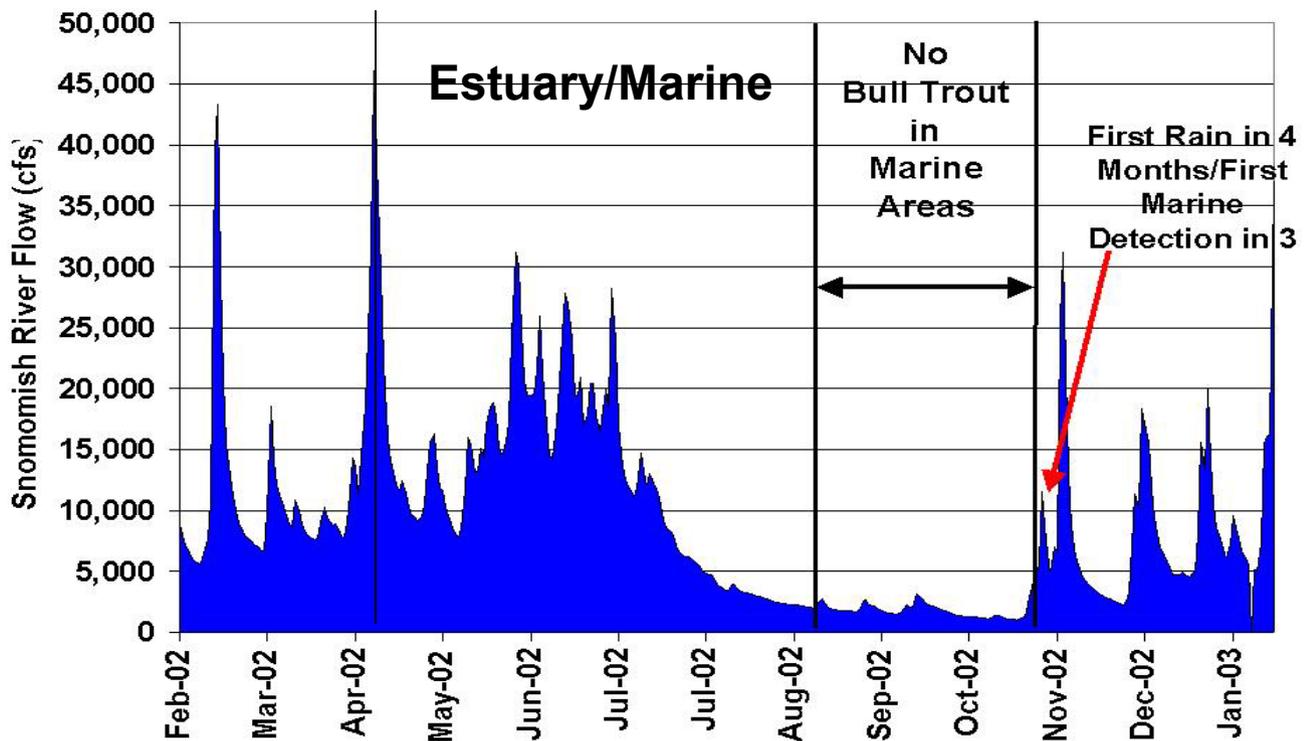
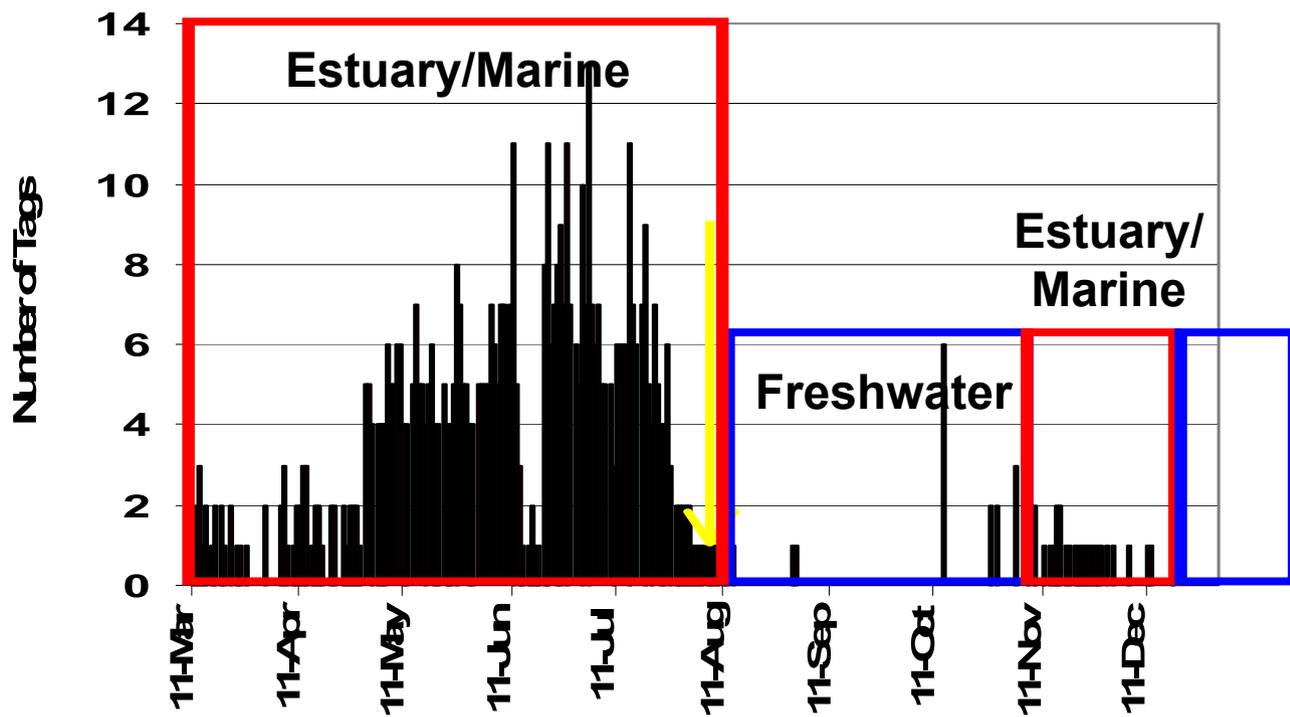
- **During marine residency, fish displaying site fidelity show scales of movement along shoreline areas by season and within a day. Figure 8 shows shoreline position of one fish in two years. Figure 9 shows aerial photos of same area with selected fish locations. During weekly surveys in 2003 (April 27-June 27) this fish showed a shoreline range of 1000 m. Within a day this fish moved up to 100-400 m.**
- **Figure 10 (top) shows residency periods in estuarine and marine areas of 50 fish tagged and detected in 2002. The spring and summer residency matches the literature review very well, 49 of 50 fish left marine areas by end of July (98%).**
- **We found another brief period of marine residency in the fall triggered by weather/flow change (Fig 10 bottom). The summer/fall of 2002 was the driest in 60 years, the first rain in 4 months occurred on November 7, within hours of flow rise 2 fish re-entered marine waters and up to 10 were detected between Nov 7-Dec 18. Many of these fish simply migrated through marine areas and returned to the feeding area of the previous spring.**
- **Fish occupying any marine or estuarine area may come from three different river basins (Fig 11). These fish may have migrated 120 km along marine shorelines to seek that site.**



**Figure 8. Marine shoreline use by one fish over two seasons (2002, 2003 - left) of mobile tracking and within one day (right).**

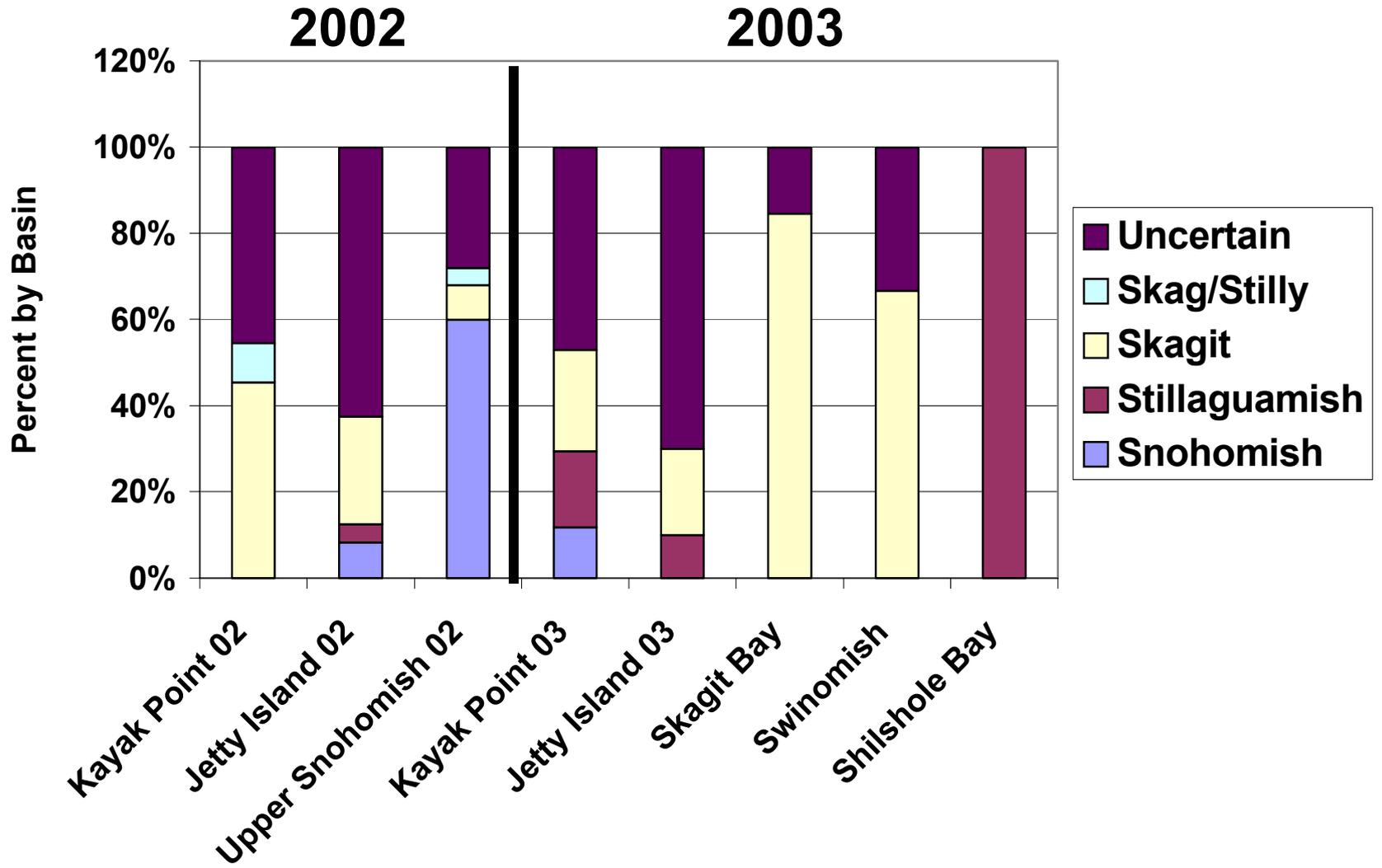
**Figure 9. Photos of selected shoreline locations for Tag 248 for 2002 and 2003 at Kayak Point.**





**Figure 10. Number of fish detected per day in 2002, periods of marine detections are outlined in red. Bottom figure shows periods of habitat use vs. Snomomish River flow.**

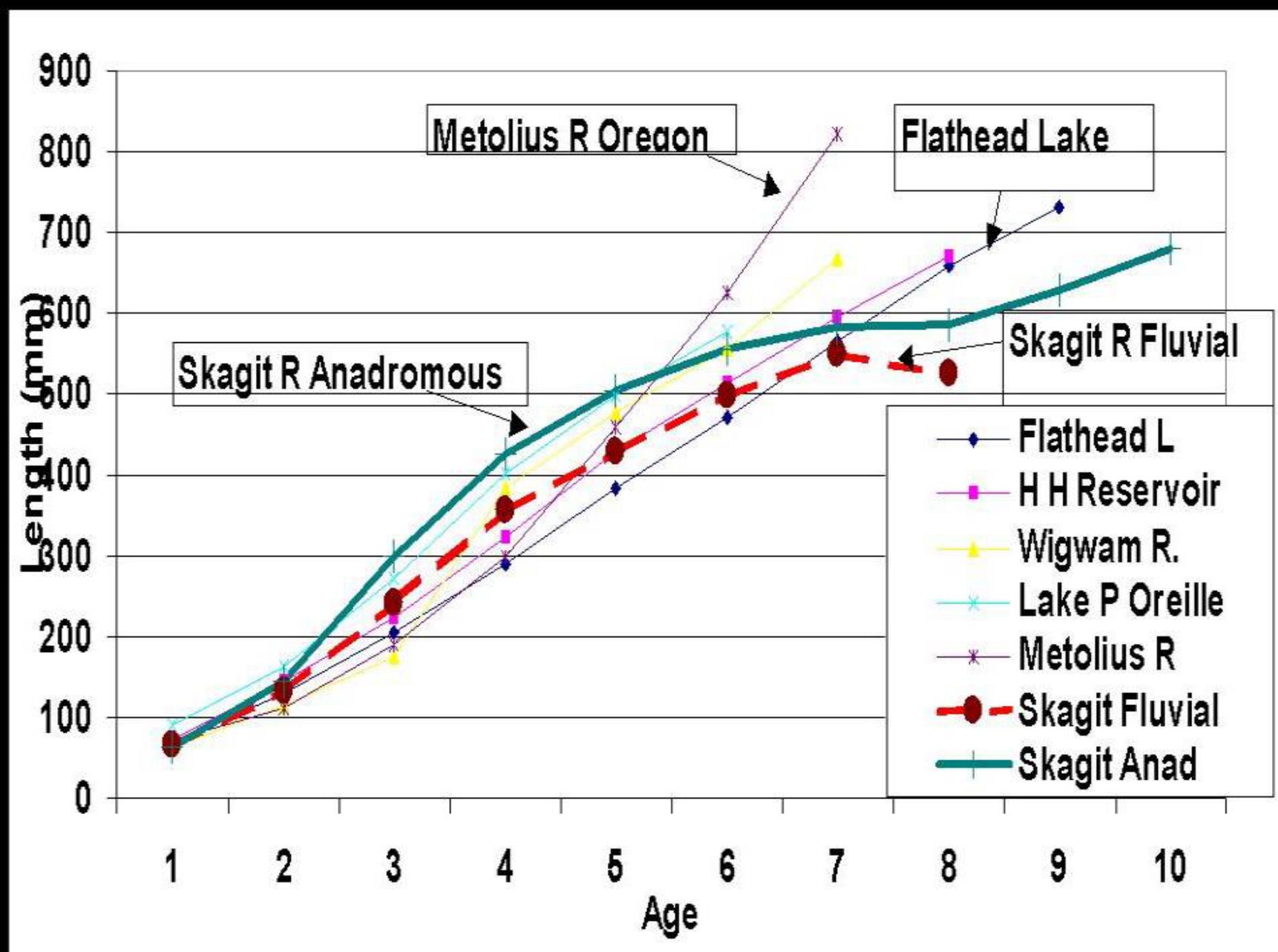
## Basin Oversummer Location



**Figure 11. River basin over summer location (once fish left marine waters which basin were they detected in).**

# Preliminary Conclusions

- Months of estuary and nearshore use are predominantly March to July. Some fish reenter marine areas briefly in the fall to return to foraging areas. In summer, fish may leave estuary/marine areas due to high temperatures.
- The highest summer temperature fish were found at was 18 C with all other fish less than 17 C – range 9.7 to 17 C. In 2002, fish migrated upriver into cooler water areas beginning in June and July. In 2003, fish migration began in late May and all but two fish had left nearshore marine areas by the end of July (warmest summer on record).
- Fish occupying any particular estuarine/marine area may come from one to three different river basins.
- Salinity in Puget Sound is not a problem for anadromous bull trout. Fish were found in the full range of salinities present in Puget Sound (1-28 ppt). Some fish occupied intertidal areas where salinity ranged from 3 ppt to 25 ppt over one tidal cycle. One depth tagged fish continually occupied areas of 26-28 ppt.
- At high tide, sub-adults and adults use intertidal mud flats for foraging, returning to deeper channels at low tide.
- Fish were found from 1 m to 20 m depths, over all substrates, many nearby to eelgrass areas. Protected areas appear to have more fish.
- Marine occupation may provide a growth advantage to bull trout over river (fluvial) rearing (Figure 12). Faster growth can lead to earlier age of spawning and greater recruitment.



**Figure 12. Bull trout length for anadromous and riverine (fluvial) Skagit River fish compared to other freshwater river populations. Anadromous fish show an increased growth rate. Adopted from Goetz (1989) and K. Craemer (2003, WDFW).**