# Coast Salish and U.S. Geological Survey Tribal Journey Water Quality Project

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# Coast Salish and U.S. Geological Survey: Tribal Journey Water Quality Project

## Introduction

The ancestral waters of the Coast Salish People, the Salish Sea, comprise a large inland sea contained within both United States (Puget Sound) and Canadian (Georgia Strait) territory. The Salish Sea is home to more than 220 species of fish, 29 species of marine mammals, more than 40 species of commercial and recreationally harvested invertebrates, and numerous resident and migratory bird species (Washington Sea Grant Program, 2000). Unfortunately, at least 60 of these marine based species are listed as threatened, endangered or of concern (Fraser and others, 2006), many of which sustained Coast Salish for millennia and are of essential cultural importance.

The cumulative impacts of human activities and climate change are deteriorating coastal ecosystems and accelerating the loss of ecologically and culturally important marine resources. Watershed modifications, coastal development and industrial activities are altering river and tidal flow, sediment transport, and nutrient delivery all across the region, leading to the break down of ecosystem functions and decreasing biodiversity, thus changing the face of the Salish Sea. A cooperative trans-boundary partnership between the U.S. Environmental Protection Agency (USEPA) and the Government of Canada has identified Salish Sea indicators of health. Several of these indicators have been noted as having degrading quality including urbanization and forest change, river, stream, and lake quality, marine species at risk, toxics in harbor seals, and marine water quality conditions (USEPA, 2008). The functioning of the Salish Sea ecosystem is increasingly threatened by ever more frequent observations and expanding zones of anoxia. The complexities of monitoring, protecting, and restoring such a large and diverse geographical area are exacerbated by a political border.

The Coast Salish Peoples and U.S. Geological Survey (USGS) have commenced on a partnership to examine water quality throughout the Georgia Straits and Puget Sound, blending tradition and science, in response to this deterioration of coastal environments and loss of essential habitats and marine resources of cultural and ecological importance throughout the ancestral waters of the Salish Sea. This report describes the Coast Salish Tribal Journey Water Quality Project, its inception, the results of the 2008 Tribal Journey project, lessons learned, and recommendations for future directions.

### *The Coast Salish Gathering*

We Are Coast Salish

*"We, the indigenous peoples of the Salish Sea, our autonomous status as sovereign Tribes and First Nations and our inherent responsibility as protectors of our Mother Earth, will continue to speak with One Voice for the preservation, restoration, and protection of the Salish Sea Eco Region for the sustainability of our sacred inherent family rights and values that have been passed on to us by our ancestors*"

- Coast Salish Gathering Mission Statement.

In 2005 the Coast Salish Gathering brought together Leaders from the Coast Salish Tribes and First Nations of Washington and British Columbia for the first time in generations to initiate a management plan to address environmental concerns, issues, and projects in the trans-boundary region of the Georgia Basin/Puget Sound, the Salish Sea. The Gathering rekindled the relationship of Coast Salish First Nations and Tribes through their traditional practices. During the Gathering, the elders reflected on the Salish Sea of their youth and the changes they have witnessed. The dialogue shared the aboriginal perspective on the current state and trends of the environment in this unique estuarine ecosystem that they call home. The objective of the Gathering was to provide a forum for Tribal and First Nation leaders to collaborate on environmental issues and share that information with governmental policy makers to assist them in making more protective and culturally sensitive decisions concerning the future of this richly endowed, yet fragile, region that we all share, the Salish Sea.

The Salish Sea is the homeland of the Coast Salish peoples and is rich in a diverse array of marine and upland resources unique to this area that sustain Coast Salish cultures and traditions. Salmon are the icon of this essential and yet endangered connection of Coast Salish people to their land and waters. Coast Salish homelands and resources are under significant pressure from population growth, industrial expansion and economic demands. Due to the serious environmental problems confronting the Salish Sea, Tribal and First Nation leaders along with Government officials engaged in a policy dialogue to come to common ground on identifying environmental issues and discuss, share and recommend policies and action in the shared region. The Coast Salish Gathering is a way for Coast Salish Leaders to come together and speak of their common concerns under one voice, Coast Salish.

Since the initial Coast Salish Gathering, two additional gatherings were conducted in 2007 and 2008. The Gatherings have continued to provide the environmental policy platform for the five governmental bodies of the Salish Sea Region (the Tribes, First Nations, State, Provincial, and Federal) to discuss the effective participation of the Coast Salish peoples in various treaties, agreements, and policies that protect the Salish Sea Ecosystem (Coast Salish Gathering, 2008). The 2008 Gathering culminated with an action agenda, under one voice, with the goals of restoring traditional foods, water quality and quantity and planning for climate change impacts for the sustainability of Coast Salish Peoples culture.

## *Coast Salish Partnership with U.S. Geological Survey*

In February 2008, the idea of mapping the surface water quality of the Salish Sea behind canoes during the Annual Tribal Journey, *the Tribal Journey Water Quality Project (TJWQP)*, was presented to Coast Salish Leaders at the third annual Coast Salish Gathering in Tulalip, WA. With unanimous approval, The TJWQP was formally adopted by the Gathering leadership. It is the first scientific effort to come out of the Coast Salish Gathering.

The objectives of the TJWQP are two fold. The first goal is to solidify the valuable partnership between Coast Salish and the USGS. The second is to integrate the scientific expertise provided by USGS with traditional means to gather and synthesize information on impacts to water quality, nearshore habitats, and Salish Sea resources in a way that would

promote capacity building for the Coast Salish. Both partners embrace the TJWQP as a way of sharing and integrating traditional ecological knowledge to protect the Salish Sea. The information collected during the annual Tribal Journeys will advise Coast Salish Leadership in making policy decisions regarding Salish Sea resources.

With the approval of the Coast Salish Leadership to move forward, project planning started right away. The scientific team began talking with Canoe Families to see who would want to participate in the TJWQP. From the beginning broad support from the Canoe Families was essential for success. Blending new and old technology creates the ideal sampling design for water quality testing. No other environmental monitoring agency sponsored by the states, provinces, or federal governments of the United States or Canada have been able to sample a trans-boundary waterway as thoroughly as the TJWQP was proposing to do. The commitment of the participating Canoe Families made this bold effort possible.

## *Tribal Journey Water Quality Project*

The TJWQP is a blending of state-of-the-art science with the traditional annual Tribal Canoe Journey to measure surface water quality across the vast area of the Salish Sea (Figures 1). Using water quality sondes, Global Positioning Systems (GPS) and traditional canoes traveling five principal ancestral waterways, Coast Salish canoe families simultaneously measured sea surface temperature, salinity, pH, turbidity, and dissolved oxygen with GPS coordinates every 10-seconds while paddling canoes along various water bodies spanning hundreds of kilometers of Puget Sound and Georgia Basin (Figure 2, 3).

The TJWQP was officially introduced to the Canoe Families in March of 2008 at the Makah Planning Meeting held in Neah Bay, WA. It was at this meeting that Project coordinators began learning about all of the aspects involved in the Tribal Journey and developing a strategy for implementing the project. The Swinomish Tribe, with the blessing of Skipper Eric Day, was the first Family to accept the tasks of the Project. From the beginning of the planning stages Eric Day was a vital resource, advising the team along the way. Squaxin Island Canoe Family agreed to participate in the Project in April, and by June Homalco and Stolo had also made a commitment to the Project.

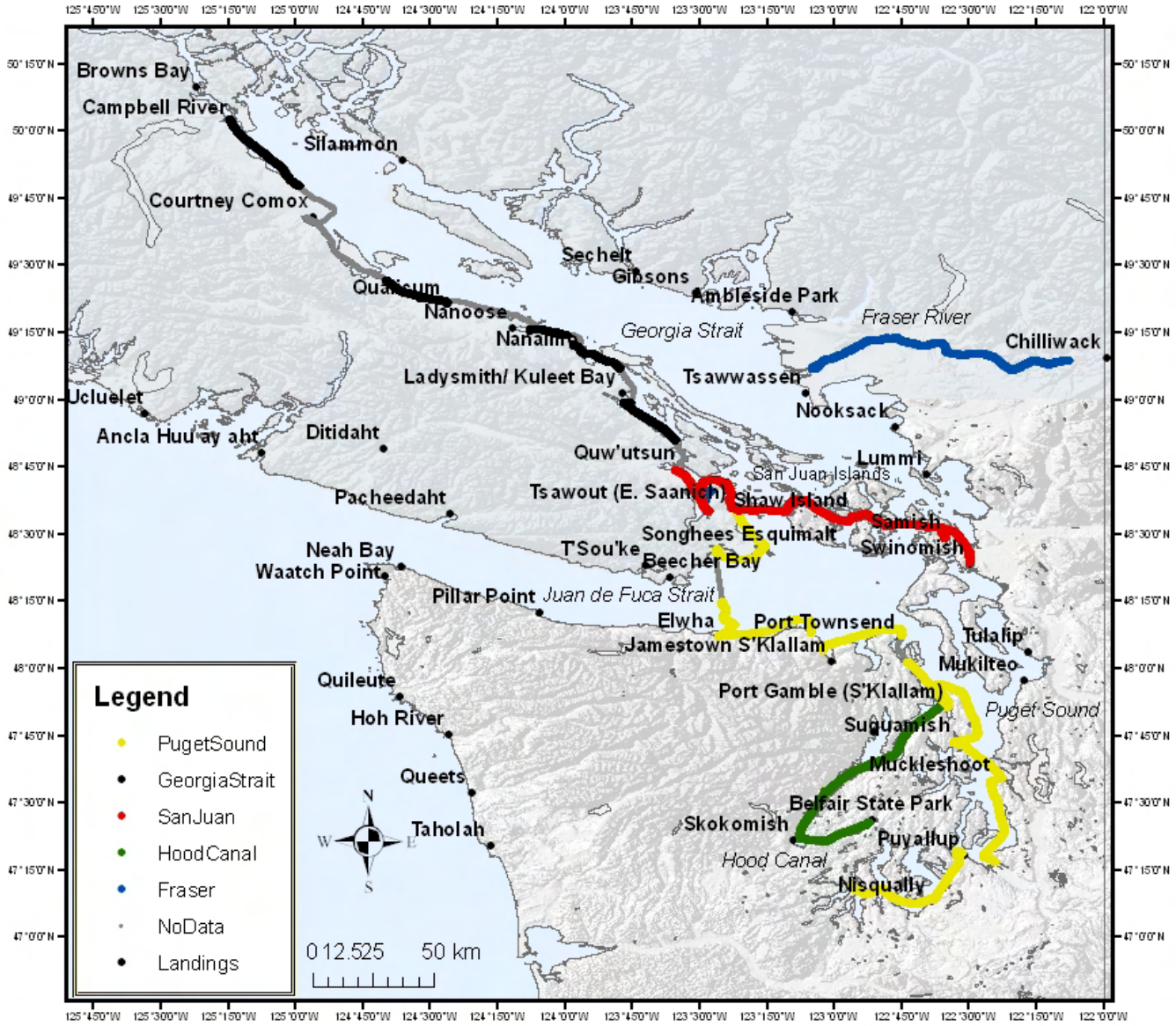


**Figure 1. Map of the five routes and coverage of water quality data collected during the 2008 Tribal Journey.**

**Figure 2. Mobilization of water quality probe in traditional canoe.**

**Figure 3. Test of water quality probe at 3rd Annual Coast Salish Gathering in Tulalip, WA.**

The Tribal Journey occurs every summer from July through the first week of August and each year a different final landing destination is chosen. For 2008 the final destination was the Quw'utsun territory, located on Vancouver Island, British Columbia. During the 2008 Journey, the TJWQP demonstrated that the water quality science could be conducted and successfully acquired over 43,000 data points along over 600 miles of Coast Salish waterways. These data provide a baseline dataset of water quality across the Salish Sea from which "hot spots" of water quality concern were identified. With the success of the 2008 Journey, planning is underway for 2009 and 2010.

### *The Salish Sea*

The Salish Sea has a surface area of 16,925 square kilometers with 4,740 kilometers of coast line. At its deepest point the depths reach 270 meters (SeaDoc, 2008). The Salish Sea watershed is outlined by the Olympic Mountains, Vancouver Island Ranges, and the Cascade Mountains and roughly encompasses 135,000 square kilometers (Fraser and others, 2006). The Fraser River drainage accounts for one-quarter of British Columbia's freshwater input to the Georgia Strait and supports runs of all five species of Pacific Salmon (Environment Canada, 2000). The Fraser River is the largest fresh water source into the Salish Sea.

## Methods

### *Canoe Families*

The Canoe Families that participated in the TJWQP were Squaxin Island (Shelton, WA), Swinomish Tribe (LaConner, WA), the Stolo People (Chillawack, BC), Homalco Nation (Campbell River, BC), and the Skokomish Tribe (Skokomish, WA). With permission of the Skokomish Tribe, Eric Grossman (USGS) paddled a kayak through Hood Canal, WA on the Tribes behalf. Members of the Canoe Families included at least one, but in many cases more than one, Skipper, a crew ranging in ages from youth to elders, and a Water Quality Technician.

The Water Quality Technicians for the Tribal Journey were Tiffany Hoyopatubbi traveling with Squaxin Island, Tara Tisdale traveling with the Stolo People, Clinton Charlie

traveling with Homalco Nation, and Eric Grossman traveling Hood Canal and also with the Swinomish Tribe. For the first TJWQP, Technicians were selected for either (1) their experience with water quality testing equipment or (2) their experiences working for and/or with Tribes and First Nations. It was very important that the Canoe Families accept the technician as a part of their Family and for the technicians to not let the TJWQP interfere with the cultural and healing aspects of the Tribal Journey. The Technicians also had to be physically able and comfortable with being on the open water for six or more hours at a time.

## *Geographic Scope and Routes*

The routes and participating Canoe Families for the TJWQP were chosen according to two main criteria: (1) canoe families traveling the greatest extent of Salish Sea and (2) the Canoe Families willingness to participate in the Project. In most cases planning for the annual Tribal Journey takes place over the course of an entire year, and in many cases the official routes are not finalized until a few weeks before the Journey is set to begin. The planning process takes place both within the individual Canoe Families and as a group at Canoe Family Planning Meetings which are hosted by various Tribes and First Nations around the region and held monthly. The Canoe Families carefully create the yearly routes, which follow the traditional pathways of their ancestors through the Salish Sea. The TJWQP in no way intends to interfere with this planning process. The TJWQP is an added component to the Tribal Journey.

## *Equipment*

Water quality measurements were carried out using YSI Environmental 6920 V2-2 sondes. The sondes have two optical ports, one for a ROX optical dissolved oxygen sensor and the other an optical YSI 6136 turbidity sensor, along with the standard temperature, conductivity, specific conductance, salinity, resistivity, total dissolved solids, pH, and oxidation reduction potential, parameter capabilities (See Appendix I for specifications). One of the YSI 6920 sondes had depth capabilities. The main water quality parameters of interest for this report are water temperature, dissolved oxygen, salinity, pH, and turbidity.

Data collected by the sondes were logged onto high memory YSI 650 display units. Display units were connected to the Sonde using a field cable. Garmin GPS units were connected to the YSI 650 display using a YSI 6115 GPS cable to incorporate position information directly into the water quality data files.

Before instrument deployment each morning, the YSI 6920 sondes were audited and calibrated to ensure accuracy of the data collected, and to correct any instrument drift. The calibration and audit table can be found in Appendix VII. Calibration procedures were performed according to manufacturer recommendations and outlined in the Tribal Journey Operations Manual. Dates and times for the Sonde, display, and GPS unit were synchronized before each deployment to ensure uniformity in the data between the different tracks.

The platform for deploying the Sonde was a Coast Salish canoe. A canoe is the ideal platform for conducting water quality testing because they are, by nature; slow moving vessels that use no form of motorized propulsion that either contaminate the water or create turbulence, affecting water quality readings.

The sonde was attached to the back of the canoe using a cord, either attached to the Skipper's seat or a fixed attachment on outside of the canoes. The display unit and GPS unit remained on the canoe inside a dry bag where the technician could check the status periodically. The sondes were kept inside the canoe until after the launching ceremony and put into the water when the canoes began the daily journey. The sondes were towed within the top half meter of the water column, as the objective was to monitor the surface waters along the Tribal Journey routes.

## *The 2008 Tribal Journey*

The Tribal Journey officially started the first week of July 2008 when the first group traveling from the North left Bella Coola, British Columbia. Squaxin Island, the first tribal canoe to start the Journey with a water quality probe left the shores of the Squaxin Island Reservation early the morning of July 15, 2008. Swinomish was the next Canoe Family to start the Journey, leaving July 22, 2008, followed by Homalco leaving Campbell River July 23, 2008, and Stolo leaving Chilliwack July 24, 2008. All Canoes were finished with their Journey on July 28, 2008 at the final landing site in Quw'utsun (Cowichan) territory (Duncan, British Columbia). Table 1 summarizes the landing sites for each of the routes traveled where the waters were tested.

**Table 1. Landing dates and locations of the Canoe Families during the 2008 Tribal Journey.**

| | Canoe Family | | | | |
|---|---|---|---|---|---|
| | Squaxin Island | Swinomish | Homalco | Stolo | Hood Canal |
| Date | Landing Destination | | | | |
| July 15, 2008 | Nisqually | | | | |
| July 16, 2008 | Puyallup | | | | |
| July 17, 2008 | Muckleshoot | | | | |
| July 18, 2008 | Rest | | | | Eldon |
| July 19, 2008 | Suquamish | | | | Poulsbo |
| July 20, 2008 | Port Gambel S'Klallam | | | | Port Gambel S'Klallam |
| July 21, 2008 | Port Townsesnd | | | | |
| July 22, 2008 | Jamestown-S'Klallam | Samish | | | |
| July 23, 2008 | Elwah | Shaw Island | Courtney Comox | | |
| July 24, 2008 | Rest | Roche Harbor | Beecher Bay | Fort Langley | |
| July 25, 2008 | Songhees | Rest | Nanoose | Port Mann | |
| July 26, 2008 | Tsawout | Tsawout | Naniamo | Ladner | |
| July 27, 2008 | Tsartlip | Tsartlip | Ladysmith | Tsartlip | |
| July 28, 2008 | Quw'utsun | Quw'utsun | Quw'utsun | Quw'utsun | |

## *Data Acquisition and Quality*

Squaxin Island pulled the longest route in the study with a total of 12 days on the water. Swinomish pulled six days, Homalco pulled six days, Stolo pulled five days, and Hood Canal three days. Canoes typically left in the mornings, some time between 6:00am and 11:00am, and landed in the afternoon into evening sometime between 2:00pm and 9:00pm. Travel times depended on the distance between landing sites, weather conditions, currents, and pulling ability of the Canoes' crew. During this time period the tide regime was characterized by early morning and late afternoon high tides, therefore a large proportion of the samples collected reflect environmental conditions during falling tides.

There were three levels of data processing. After data files were collected and downloaded by the project coordinator the first step was to filter data for points when the Sonde was not in the water and erroneous GPS coordinates (which occurred periodically due to a lack of satellite coverage in certain areas). Turbidity levels were very low along most of the Journey resulting in negative turbidity readings. YSI 6136 Turbidity probes were less reliable in areas where turbidity levels were below 10 FNU. Negative recorded values for turbidity were reported as 0.0 FNU. Following this processing, data were mapped in Google Maps and posted on the Web at the US Geological Survey's Washington Water Science Center (http://www.usgs.gov/coastsalish).

Where locations were not collected in either the YSI data file or the GPS data file, positions were reconstructed using GIS, as the final data processing step. This was done using known start and ending locations of the daily tracks, periodic waypoints taken along tracks and through conversations with technicians and other clues provided in the data files (for example fresh water sources, break times, or duration of data files).

### *Water Quality Assessment*

To evaluate the variation in the water quality across the study area we evaluated the data against an established set of regulatory standards. Washington State has developed a set of water quality standards to protect the marine and fresh surface waters of the state and specific levels of protection are designated by aquatic life uses for marine surface waters. For marine surface waters, aquatic life use designations are classified as being of extraordinary quality, excellent quality, good quality, and fair quality. The marine surface water results from the TJWQP were compared to Washington State water quality standards and results are reported in this document for temperature, dissolved oxygen, and pH. Turbidity results are not evaluated against water quality standards at this time due to lack of data to support background level measurements. There are no criteria set for salinity. (WAC-173-201A-200 fresh waters and WAC-173-201A-210 marine waters).

## Results

In total 43,473 data points were collected, capturing surface water temperature in degrees Celsius (°C), dissolved oxygen in milligrams per liter (mg/L), pH in standard units, salinity in parts per thousand (ppt), and turbidity in Formazin Nephelometric Units (FNU) information, during the July 2008 Tribal Journey. The five canoes pulling during the TJWQP covered 607 miles of Coast Salish territory over a two week period between July 15 and July 28, 2008. Of the 607 cumulative miles traveled data was collected for 84 percent (%) of the miles attempted. The data results presented in this report are intended to summarize the data snap shot of the Salish Sea.

Weather conditions for the Salish Sea region during the 2008 Tribal Journey were typical for the Pacific Northwest Eco Region during the month of July. The Fraser River valley experienced warm air temperatures between 23°C and 27°C (73 degrees Fahrenheit (°F) to 80°F) with calm winds. The southern Salish Sea region experienced cooler temperatures in the mornings, 12°C to 14°C (53°F to 57°F), warming into the afternoon to 20°C (68°F). The skies were sunny to partly cloudy over the two week period with light to breezy wind conditions on the water. The San Juan Island track weather patterns were similar to the

southern Puget Sound track during the time period with air temperatures between 16°C and 20°C (60°F to 68°F), partly cloudy skies with light to breezy wind conditions.

## *Results by Track*

Each of the Canoe Families chosen to participate in the TJWQP came from territories at the furthest extents of the Salish Sea from the landing in Quw'utsun. As each of the families travel from landing to landing, the geographic areas covered will be referred to as tracks, and represent the individual water bodies that make up the Salish Sea. Below is a summary, by track, of the surface water quality conditions for parameters temperature (°C), salinity, pH, turbidity (FNU), and dissolved oxygen (mg/L) of the Salish Sea during the 2008 Tribal Journey, July 15, 2008 to July 28, 2008.

### Puget Sound

The Squaxin Island Tribe left their home territory for Quw'utsun territory on July 15, 2008. Their Journey consisted of 12 days and 242 miles of travel before the final landing on July 28, 2008. Squaxin Island, of all the participating Canoe Families, traveled the furthest carrying a water quality sonde. Most travel days Squaxin Island would launch between 7 and 8 am and land at the next destination in the afternoon. Data was collected by Squaxin Island for 210 miles of the 242 miles traveled, or 86.7% of the attempted Puget Sound track. Of the missed data collection, 14 of the miles were due to foul weather and unsafe conditions for the pullers traveling across the Juan de Fuca Strait, and the remaining missed data were due to technical errors. A total of 18,586 data points were collected for the track. Of those data points, 16.7% of the GPS coordinates had to be reconstructed due to the technical errors (Figures 4-8).

Temperatures along the Puget Sound track were generally of excellent quality standard for marine surface waters in the month of July. The average temperature along the entire track was 13.30°C, with a maximum temperature of 19.29°C and a minimum temperature of 9.00°C (Appendix II). The maximum temperature was recorded on July 27 just before the landing at Tsartlip. Less than 9% of the surface samples resulted in temperatures greater than 16°C (excellent water quality standard), and less than 1% were above 18°C (good water quality standard).

Puget Sound track surface water salinity averaged 29.23, and ranged between 32.51 and 5.66. The Puget Sound is considered an estuarine environment and salinities normally vary between fresh water [less than (<) 0.05] and marine water [greater than (>) 30] salinity levels. Minimum salinities were generally recorded when the canoe traveled past a river delta.

The pH levels in Puget Sound were relatively consistent throughout the region. The median pH reading for the Puget Sound region was 8.06 standard pH units. The maximum pH, recorded July 19, was 8.55 pH units and the minimum, recorded July 17, was 7.26 pH units. Only 4 total readings for pH were 8.50 or greater for the Puget Sound track. The pH levels between 7.0 and 8.5 are generally regarded as the optimal range for maintaining extraordinary, excellent, and good quality ecosystem processes in marine surface waters.

Turbidity levels across the Puget Sound were low during the two week period of sampling. The average turbidity for the Puget Sound track was 13.08 FNU and a median

reading of 0.2 FNU, with a maximum recording of 1983 FNU and a minimum of 0 FNU. The highest daily average for turbidity was 93 FNU, calculated for July 25, they day Squaxin Island crossed the Juan de Fuca Strait. The weather conditions for July 25 were very windy, which may have stirred up and transported sediments during the sampling time. The technician for Squaxin Island, on a majority of the Puget Sound track, noted high levels of algae and plankton in the water column during the sampling days.

The dissolved oxygen levels in the surface waters of Puget Sound were generally of acceptable levels to maintain an extraordinary water quality status during the 2008 Tribal Journey. The track average surface water dissolved oxygen was 8.90 mg/L. The minimum recorded dissolved oxygen reading was 4.64 mg/L. The minimum reading was recorded July 26, off the eastern shores of the Saanich Peninsula near Victoria, British Columbia. Less than 0.2% of all dissolved oxygen readings for Puget Sound were below 5.0 mg/L (good water quality standard), and 2.2% of readings were less than 6.0 mg/L (excellent water quality standard).

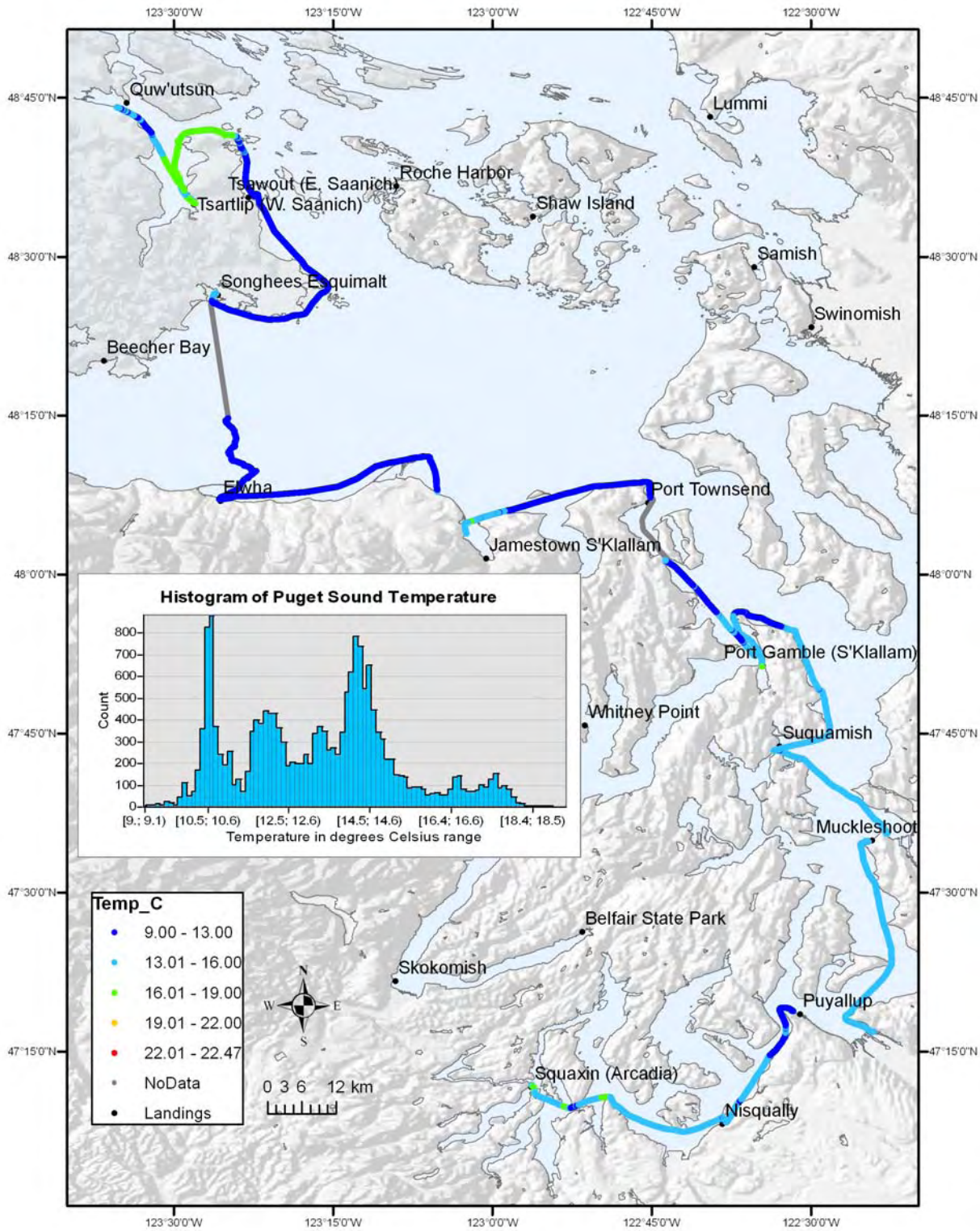


**Figure 4. Temperature recorded in degrees Celsius along the Puget Sound track from July 15 to 28, 2008 including histogram of count of readings per temperature.**

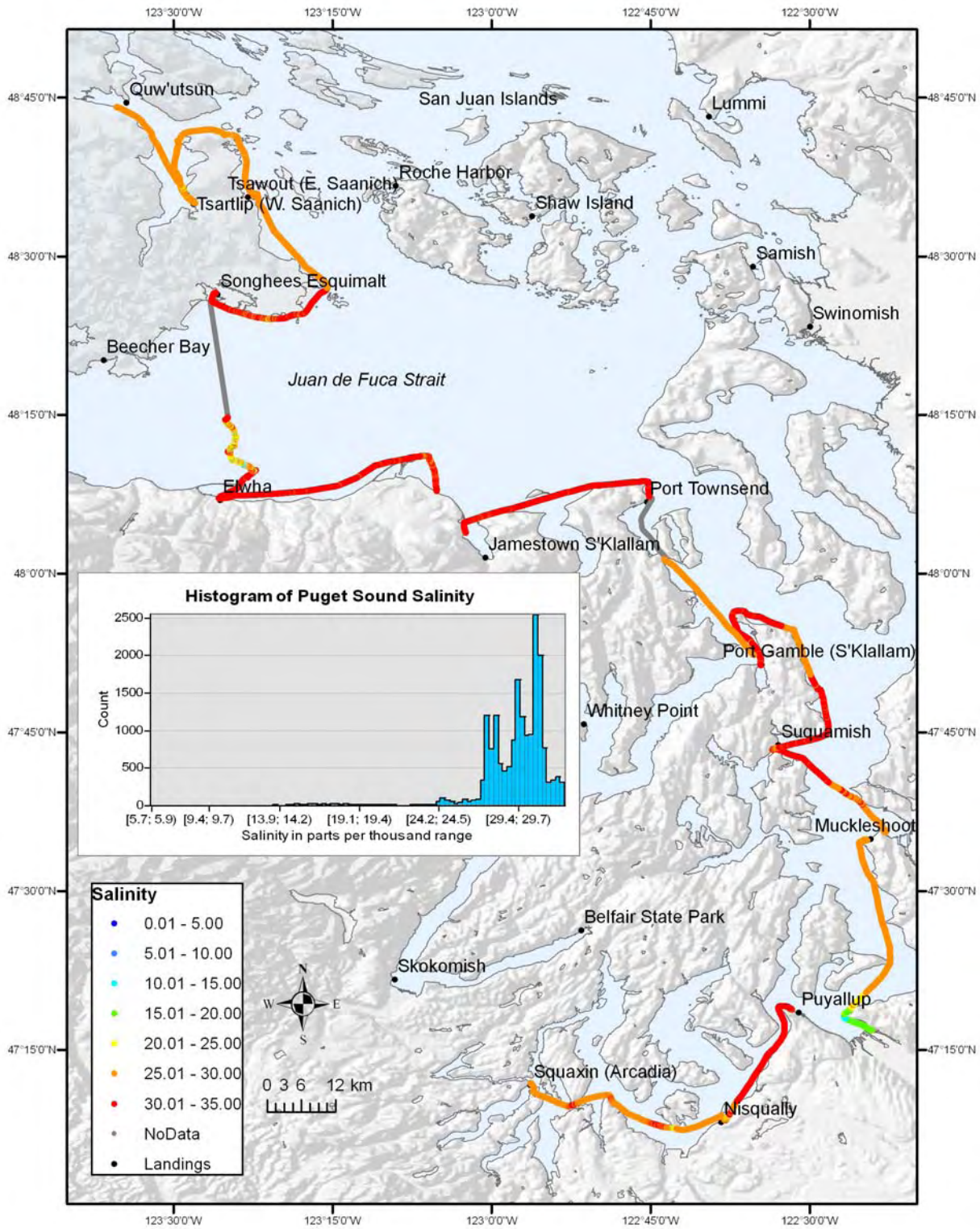


**Figure 5. Salinity recorded in parts per thousand along the Puget Sound track from July 15 to 28, 2008 including histogram of count of readings per salinity.**

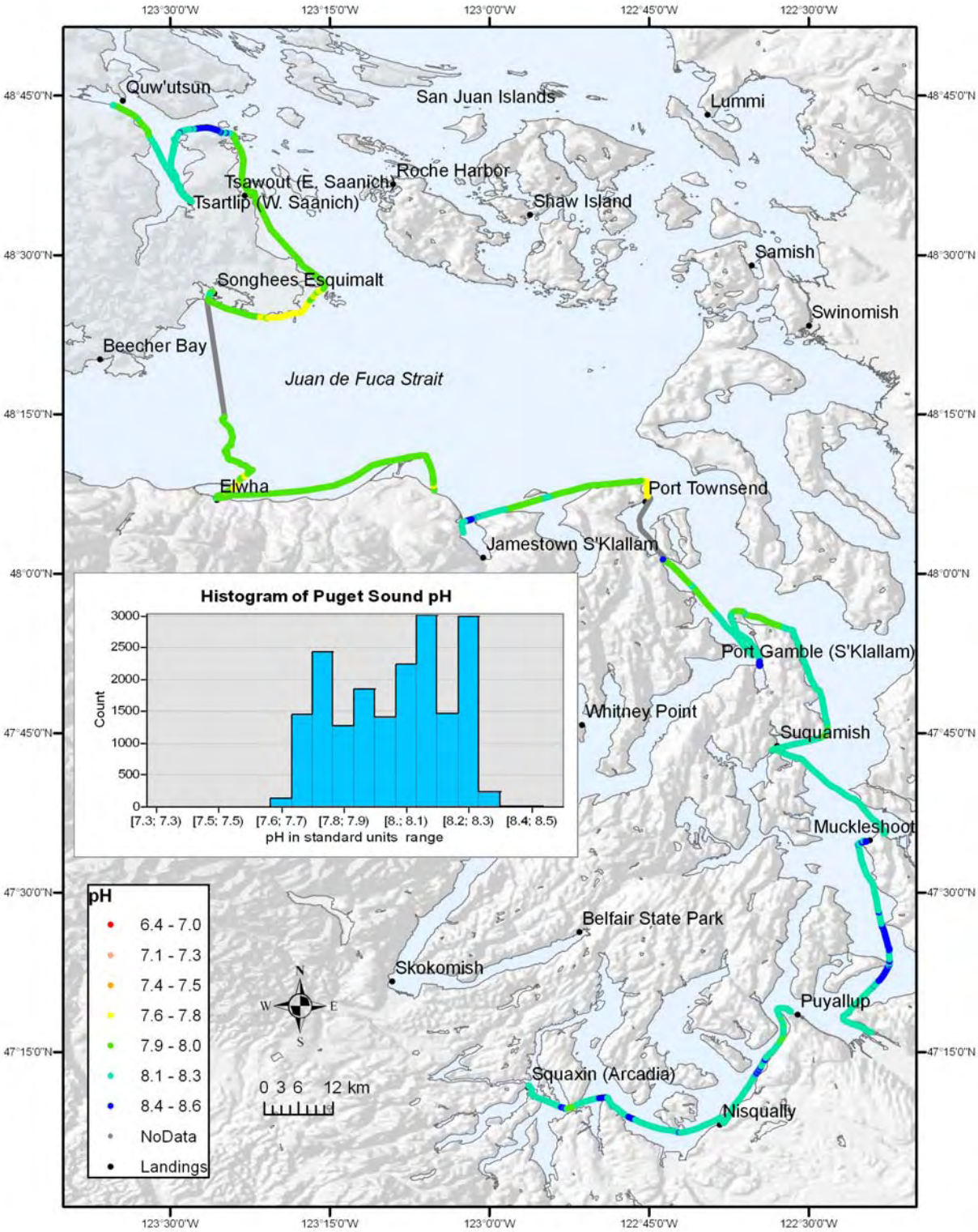


**Figure 6. pH recorded in standard units along the Puget Sound track from July 15 to 28, 2008 including histogram of count of readings per pH.**

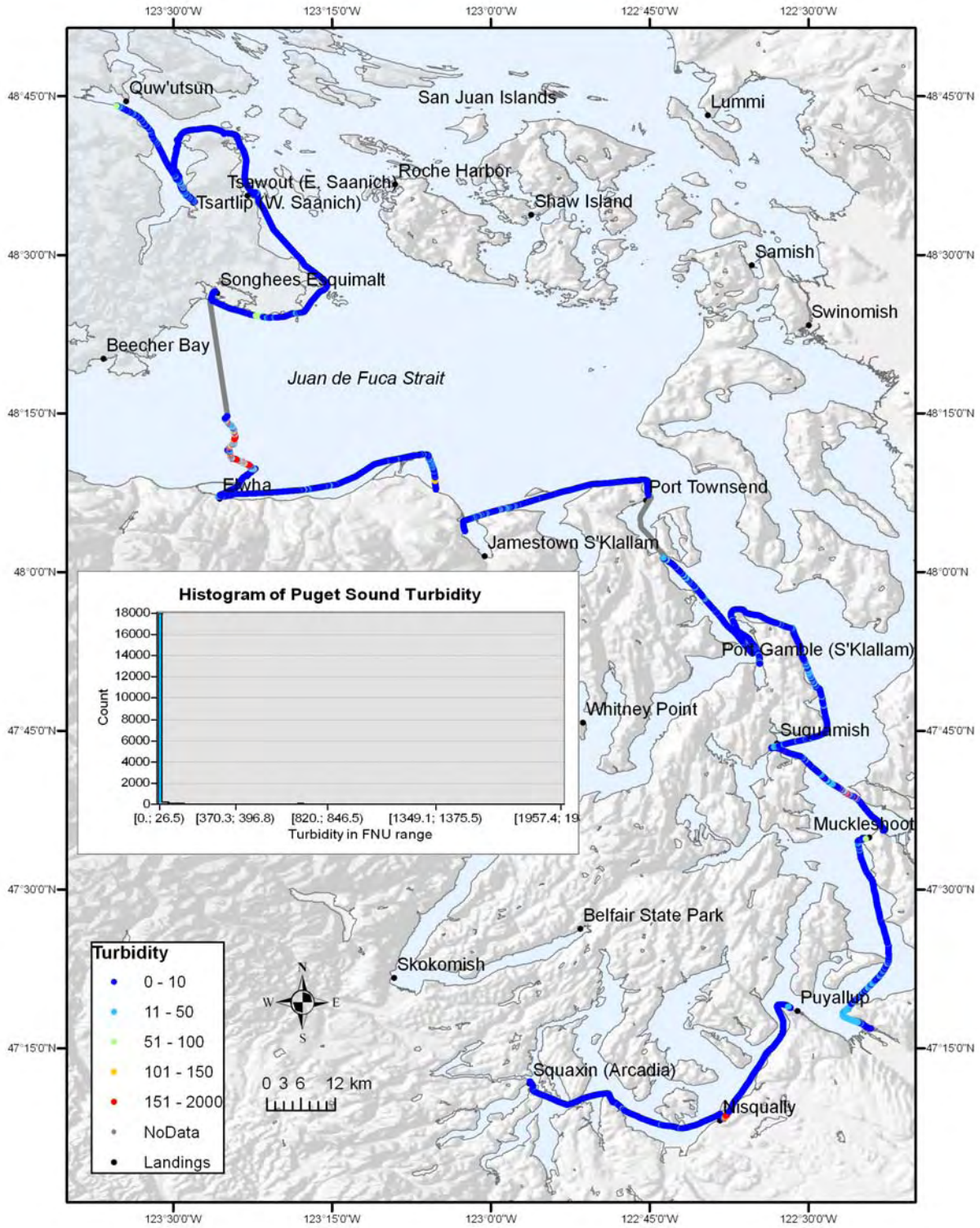


**Figure 7.Turbidity recorded in Formazin Nephelometric Units along the Puget Sound track from July 15 to 28, 2008 including histogram of count of readings per turbidity. Results mapped between Squaxin and Nisqually do not meet quality control standards and are represented here as relative differences.**

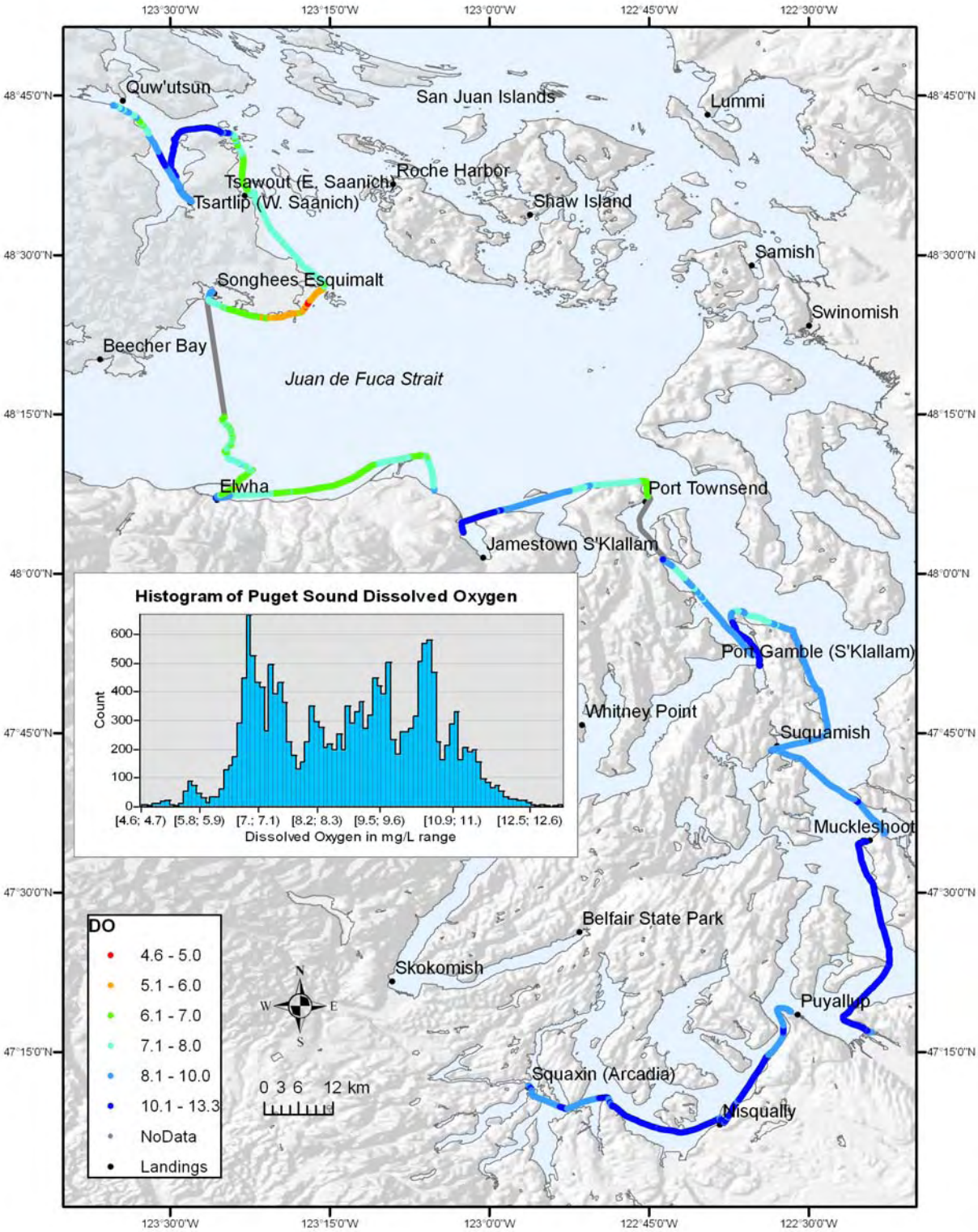


**Figure 8. Dissolved oxygen recorded in milligrams per liter along the Puget Sound track from July 15 to 28, 2008 including histogram of count of readings per dissolved oxygen.**

## Hood Canal

The Hood Canal track was the only track where data was not collected by the Canoe Family of the territory. Eric Grossman (USGS) with permission of the Skokomish Tribe traveled the Hood Canal territory by kayak. Other than the specific vessel used, the methodologies used for data collection were consistent with the other tracks. A total of 61.2 miles of Hood Canal were monitored for surface water quality between July 18 and July 20, 2008. 100% of the attempted territory was monitored and a total of 4,670 data points were collected.

There was a noticeable surface water temperature pattern in Hood Canal during the three day sampling period. The average temperature for the Hood Canal track was 18.27°C with a maximum of 21.63°C and a minimum of 14.55°C (Appendix III). The air temperatures during the three day period of sampling were seasonally cool with periods of light rain and a steady light wind. The highest temperatures were recorded in the shallow, stagnant waters at the end of Hood Canal in Lynch Cove between 8 and 9:00 am. As the track progressed away from the stagnant areas of Hood Canal temperature conditions improved (Figure 9). 3392 of 4670 (72.6%) temperature readings were above the excellent water quality standard maximum of 16°C and 2880 of 4670 (61.7%) readings were above 18°C. Hood Canal had the highest instance of temperature readings over 16°C of all the TJWQP tracks.

The average surface water salinity of Hood Canal during the period between July 18 and July 20 was 25.98, with a maximum of 29.21 and a minimum of 3.72. Salinity levels were lower in the southern reaches of Hood Canal compared with the northern region where there is more of marine influence and higher circulation (Figure 10).

The pH levels in Hood Canal surface waters were good. The median pH value was 8.26, the maximum pH was 8.46, and the minimum 7.82. This relatively narrow range of pH for the track is optimal for marine water ecosystem function and health (Figure 11).

Turbidity levels in Hood Canal during the sampling period were low. The average and median track turbidity was 1.35 FNU and 0 FNU respectively, with a maximum of 159 FNU and a minimum of 0 FNU recorded. Turbidity levels were generally higher in the northern portion of Hood Canal (Figure 12).

Dissolved oxygen levels in Hood Canal were much higher than expected for the surface waters. The track average dissolved oxygen level was 9.81 mg/L, the maximum dissolved oxygen was 13.30 mg/L and the minimum was 5.83 mg/L. Only 6 of the 4670 readings taken in Hood Canal resulted in dissolved oxygen levels below 6.0 mg/L, the excellent water quality standard minimum. Dissolved oxygen levels in Hood Canal have been heavily studied over the last few years. Dissolved oxygen levels taken within the top meter of the water column do not necessarily reflect the dissolved oxygen levels through the rest of the water column (Figure 13).

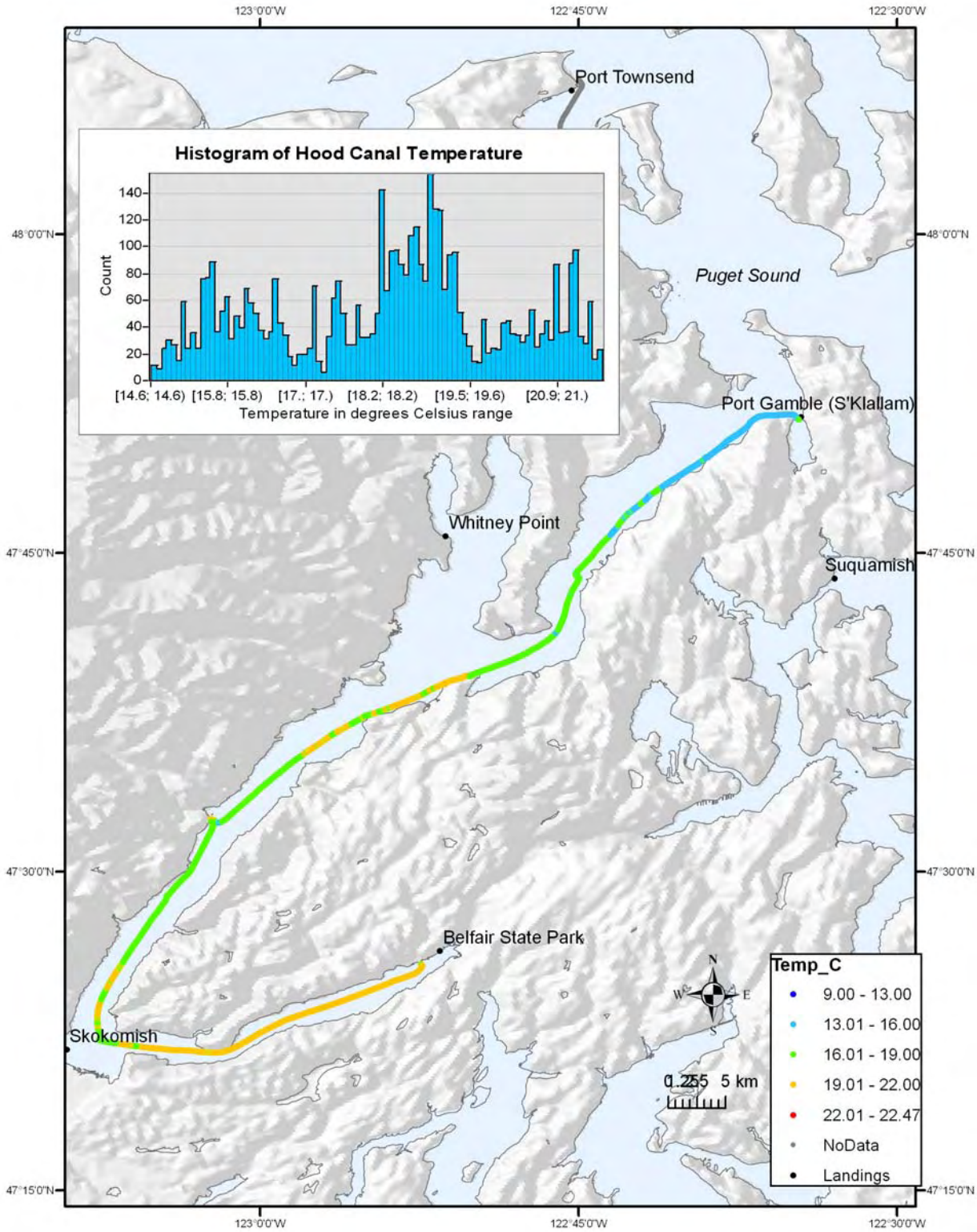


**Figure 9. Temperature recorded along the Hood Canal track from July 18 to 20, 2008 including histogram of count of readings per temperature.**

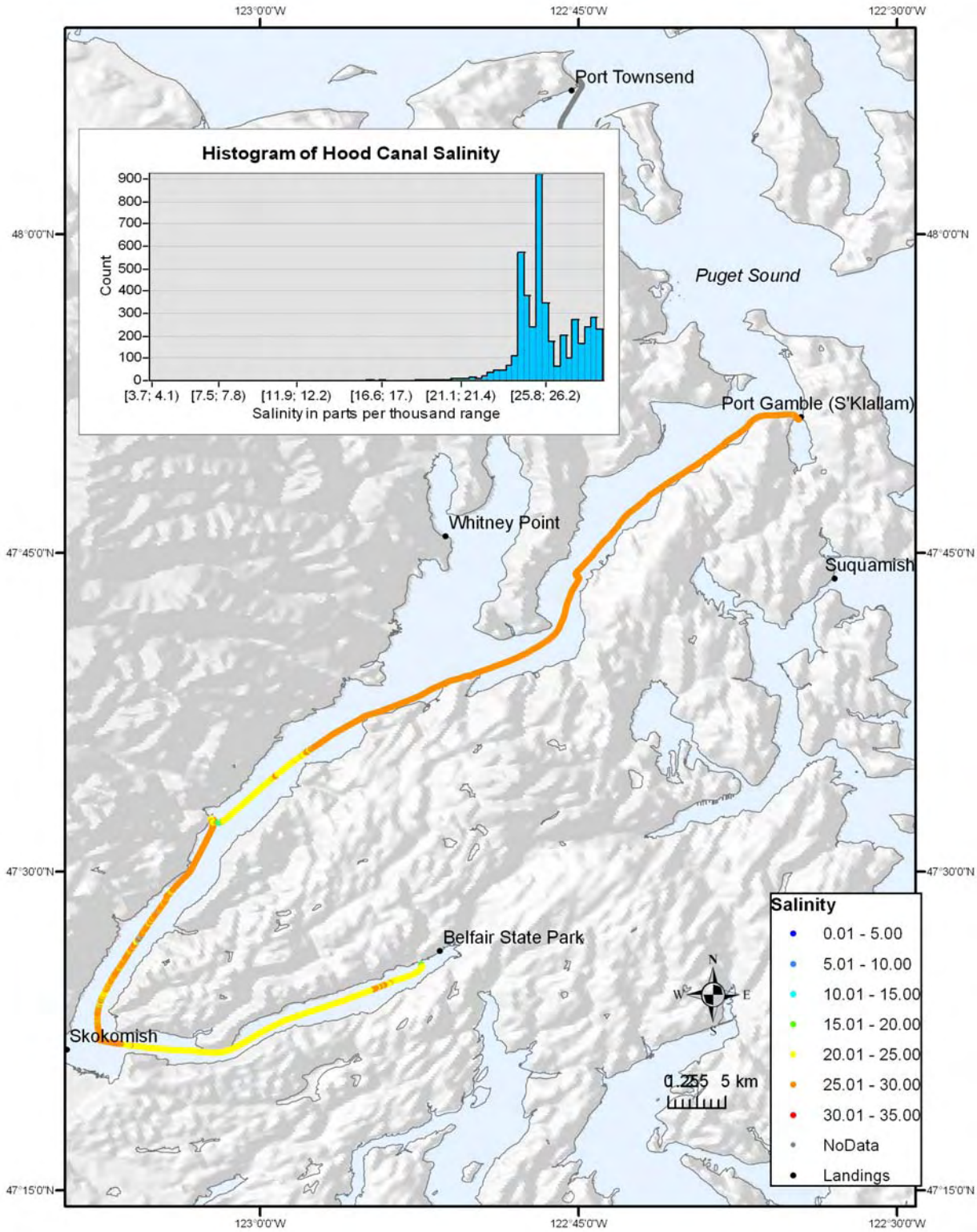


**Figure 10. Salinity recorded along the Hood Canal track from July 18 to 20, 2008 including histogram of count of readings per salinity.**

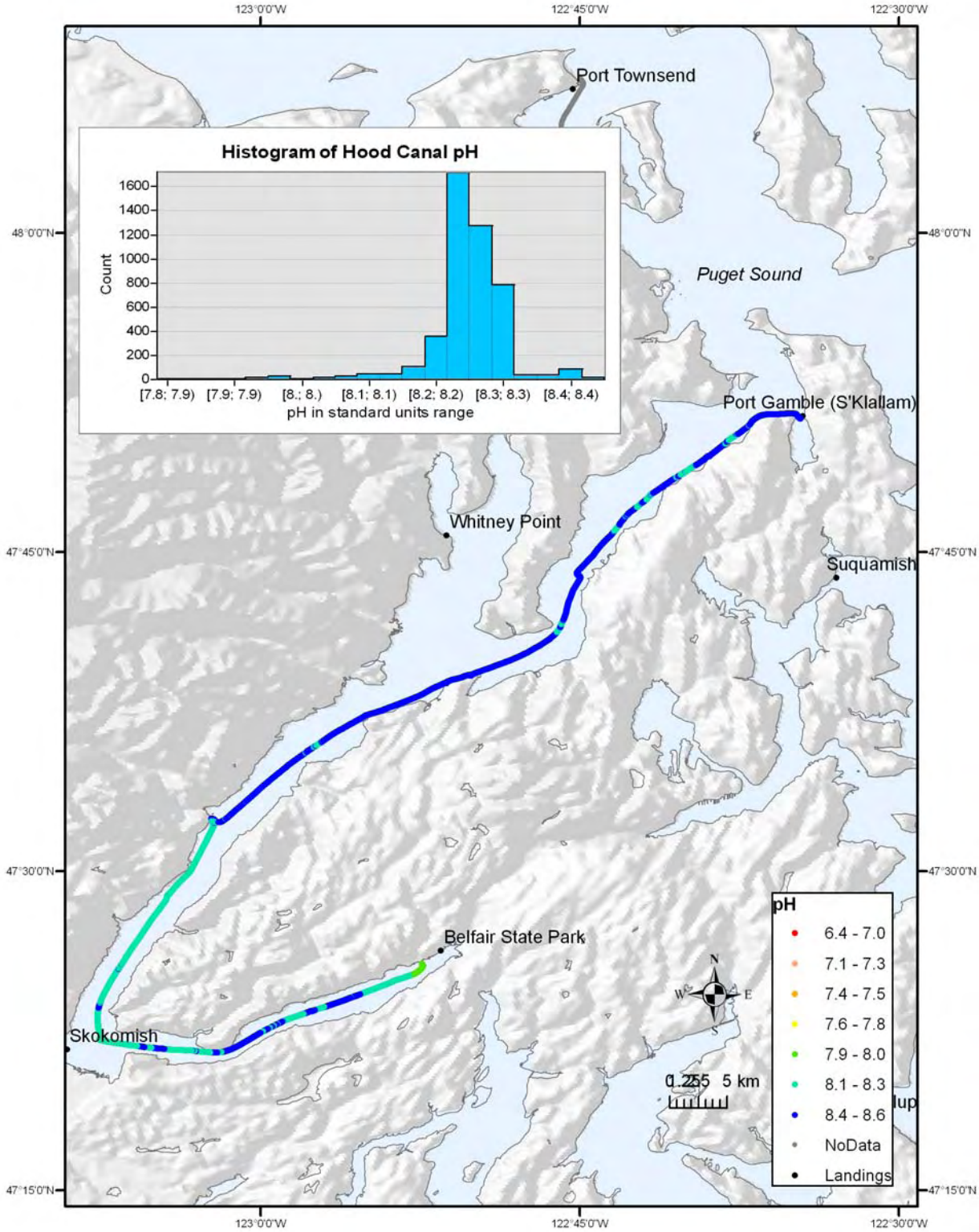


**Figure 11. pH recorded along the Hood Canal track from July 18 to 20, 2008 including histogram of count of readings per pH.**

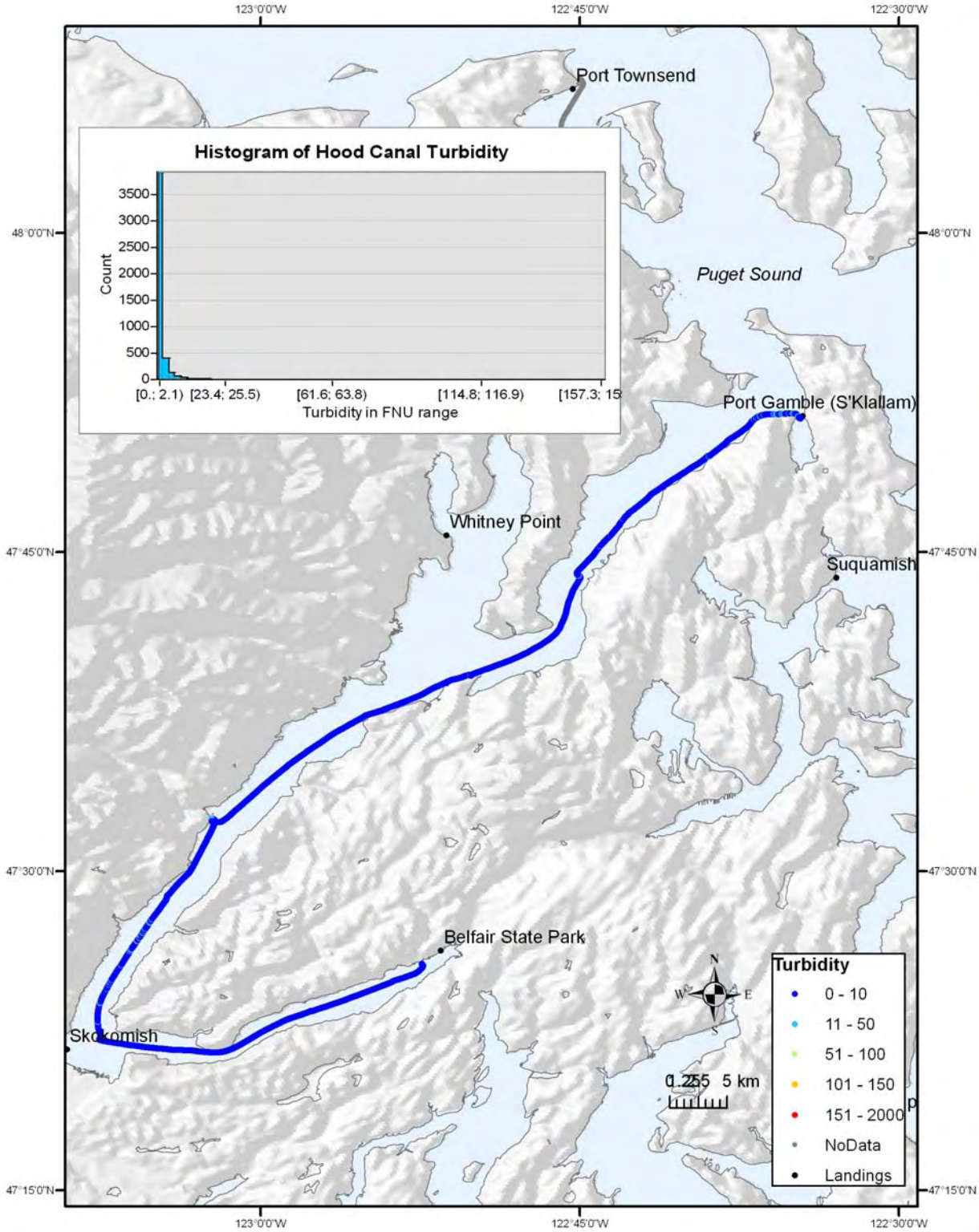


**Figure 12. Turbidity recorded along the Hood Canal track from July 18 to 20, 2008 including histogram of count of readings per turbidity.**

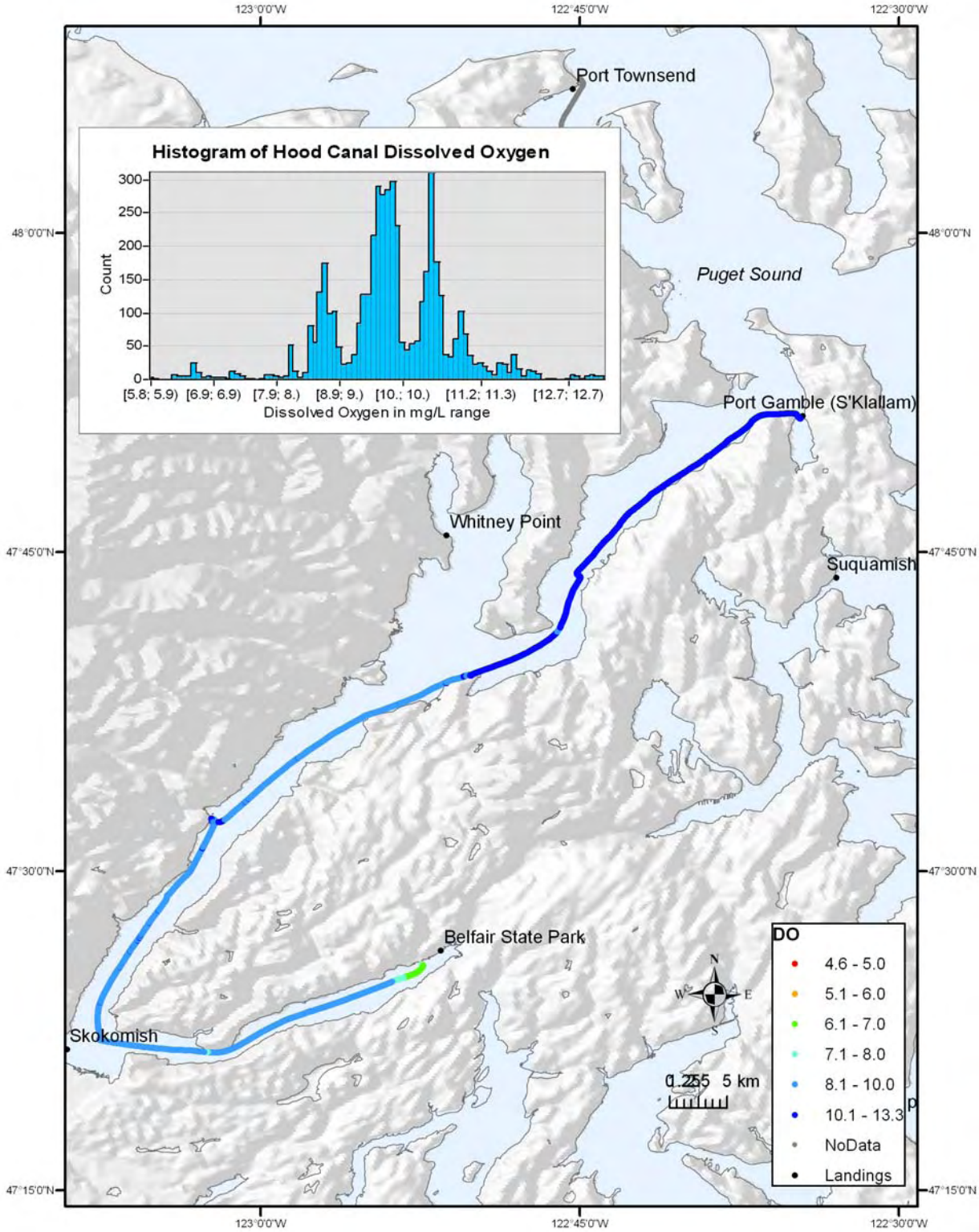


**Figure 13. Dissolved oxygen recorded along the Hood Canal track from July 18 to 20, 2008 including histogram of count of readings per dissolved oxygen.**

## San Juan Islands

The San Juan track was traveled by the Swinomish Tribe between July 22 and July 28, 2008. From Swinomish territory to the final landing, the Swinomish Canoe Family covered a distance of 97 miles. All 97 miles of track were monitored for surface water quality conditions and 9,458 data points were collected. The Swinomish Canoe Family took a day of rest on July 25 and no data was recorded that day. The results are shown in Figures 14-18.

Temperatures collected by the Swinomish Canoe Family along the San Juan track were generally of extraordinary water quality standard (Appendix IV). The average surface water temperature for the track was 12.64°C, with a maximum recorded reading of 19.09°C and a minimum of 10.22°C. The highest temperatures recorded along the San Juan track occurred on the last two days of travel, around the Saanich Peninsula and onward towards Quw'utsun territory. Of the 9,458 data points 13.5% resulted in surface water temperature readings that exceeded 16°C but less than 1% of the readings were greater than 18°C (Figure. 14).

The San Juan track salinity readings showed low variation for a majority of the track, with 92% of the readings between 25.00 and 30.69. The average salinity reading for the surface waters of the San Juan track was 28.65, with a maximum of 30.69 and a minimum of 14.30. The lowest daily average salinity was calculated from the first day of travel between Swinomish and Samish territories. The Skagit River discharges in this region and may account for the depressed salinities (Figure. 15). Average daily salinity results were depressed until Swinomish traveled to Vancouver Island for the last two days of their travel.

Average daily pH readings were noticeably lower along the San Juan track than any of the other marine waters monitored during the Journey. The median pH for the San Juan track was 7.88 pH units, with a maximum of 8.38 and a minimum of 7.56 (Figure. 16).

Turbidity readings along the San Juan route, like the other marine water routes, were generally low. The average and median track turbidity result was 7.95 FNU and 0.7 FNU respectively, with a maximum of 1,104 FNU, and a minimum of 0.00 FNU (Figure. 17).

The dissolved oxygen levels through the San Juan Islands were depressed for most of the travel, though overall of extraordinary water quality standards. The average track surface water dissolved oxygen level was 7.55 mg/L, with a maximum of 12.03 mg/L and a minimum of 5.54 mg/L. Of the 9458 dissolved oxygen readings, 539 or 5.7% of the readings were below 6.0 mg/L (the excellent water quality standard minimum). Zero readings were recorded below 5.0 mg/L. The areas of low dissolved oxygen (< 6.5 mg/L) were generally associated with open water sections of track between islands. A period of depressed dissolved oxygen was also detected near a set of jetties at the northern end of the Swinomish Reservation. This area is noted as a point of interest and will be examined during subsequent Tribal Journeys (Figure. 18).

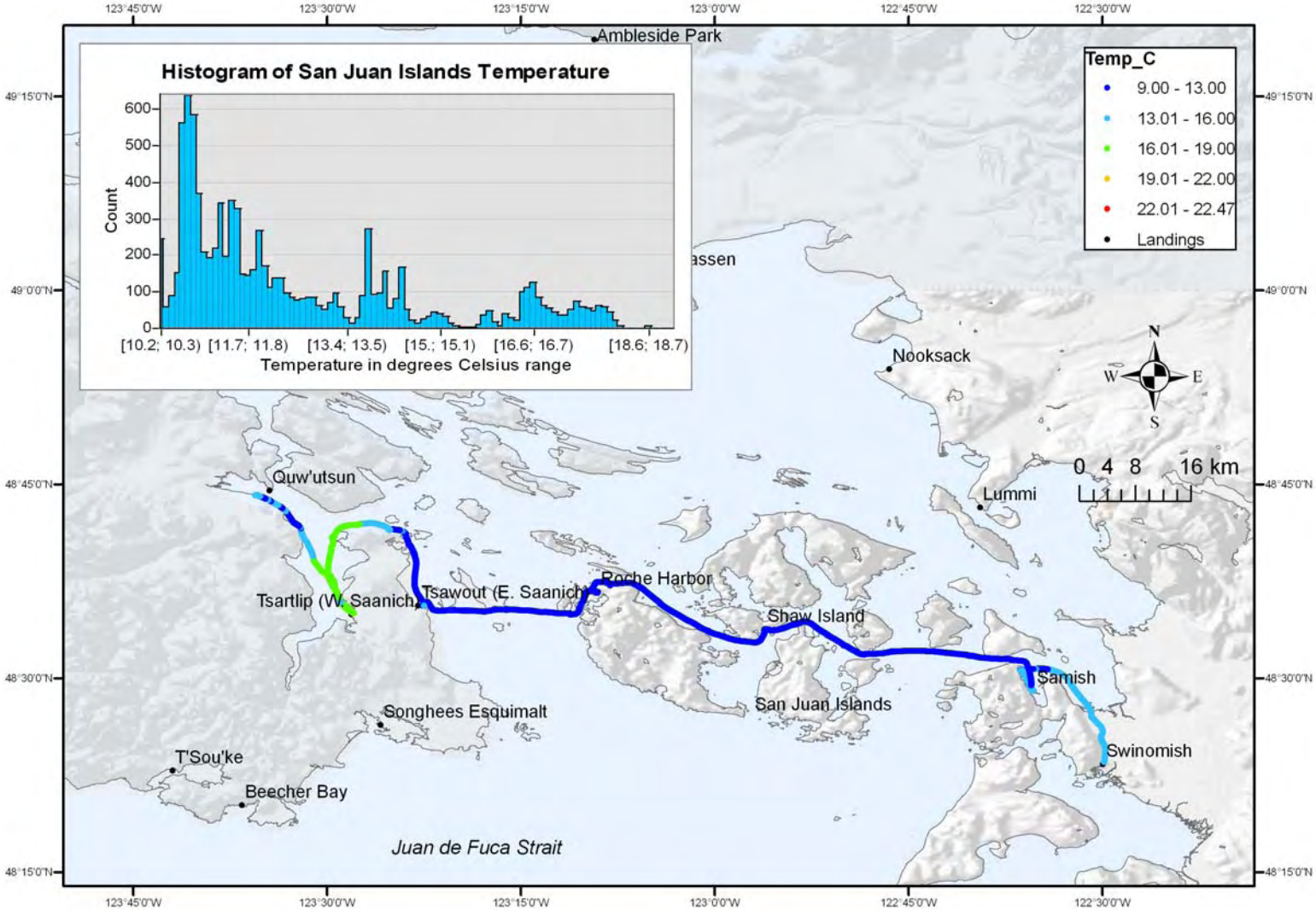


**Figure 1. Temperature recorded along the San Juan Island track from July 22 to 28, 2008 including histogram of count of readings per temperature.**

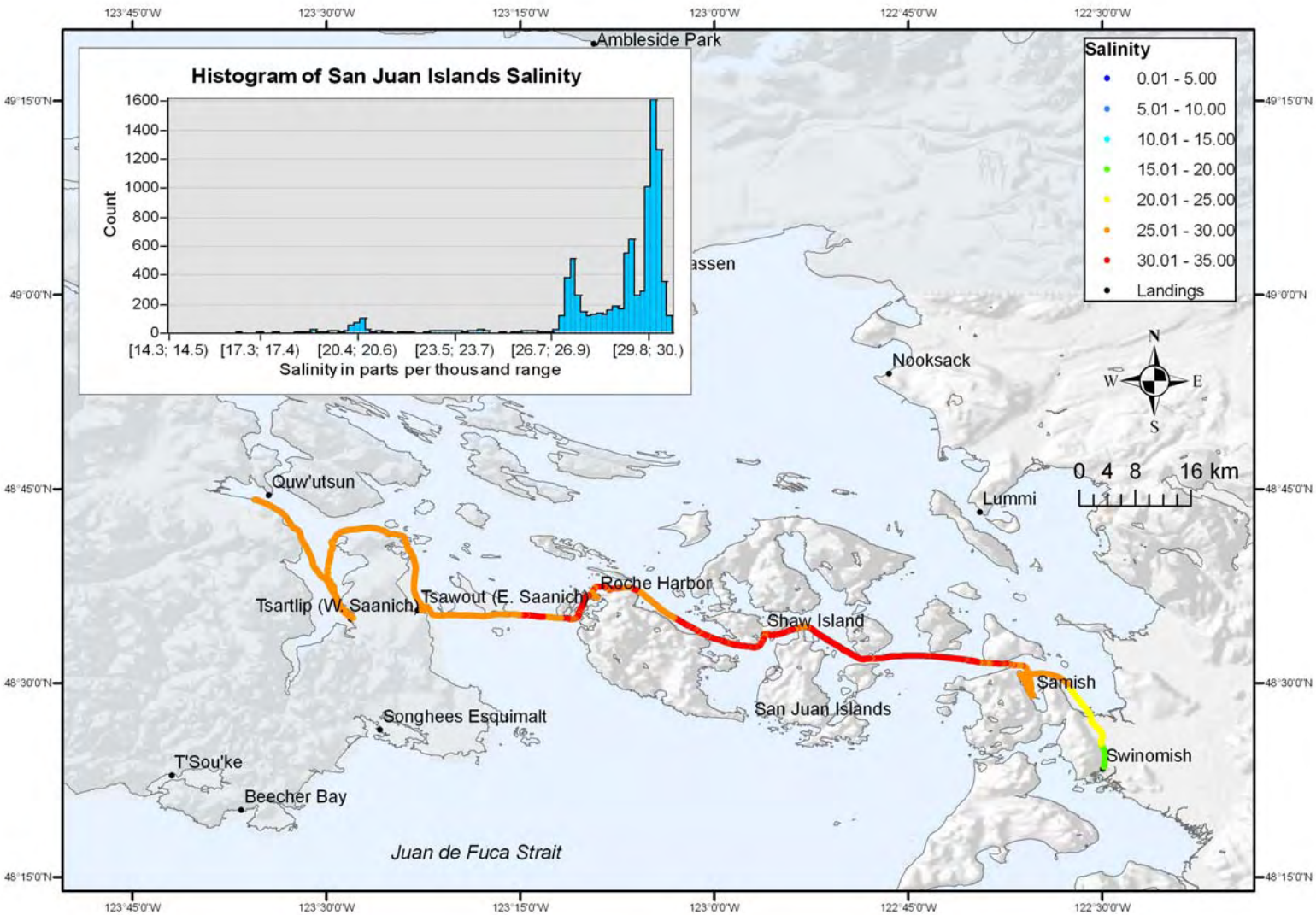


**Figure 2. Salinity recorded along the San Juan Island track from July 22 to 28, 2008 including histogram of count of readings per salinity.**

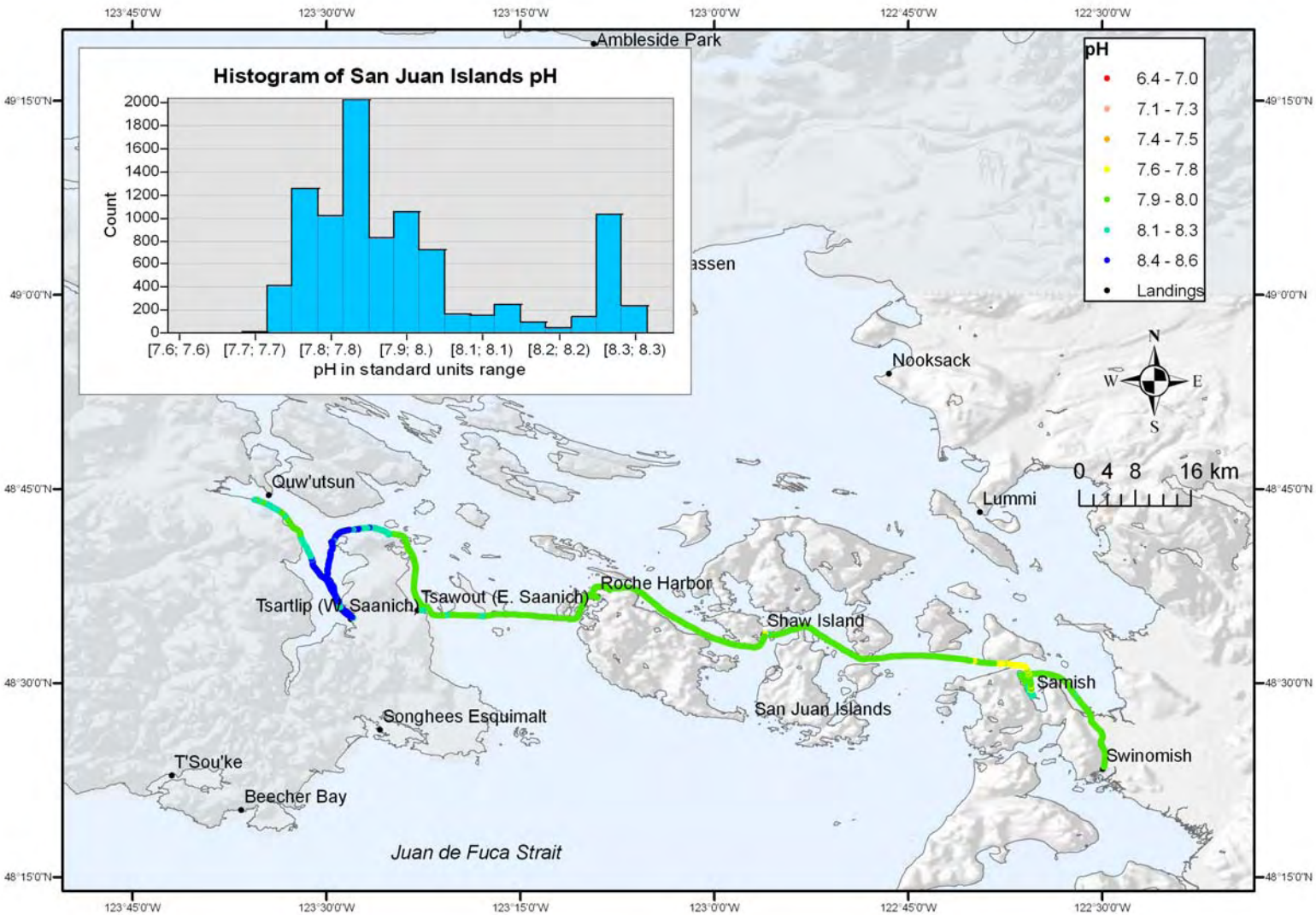


**Figure 3. pH recorded along the San Juan Island track from July 22 to 28, 2008 including histogram of count of readings per pH.**

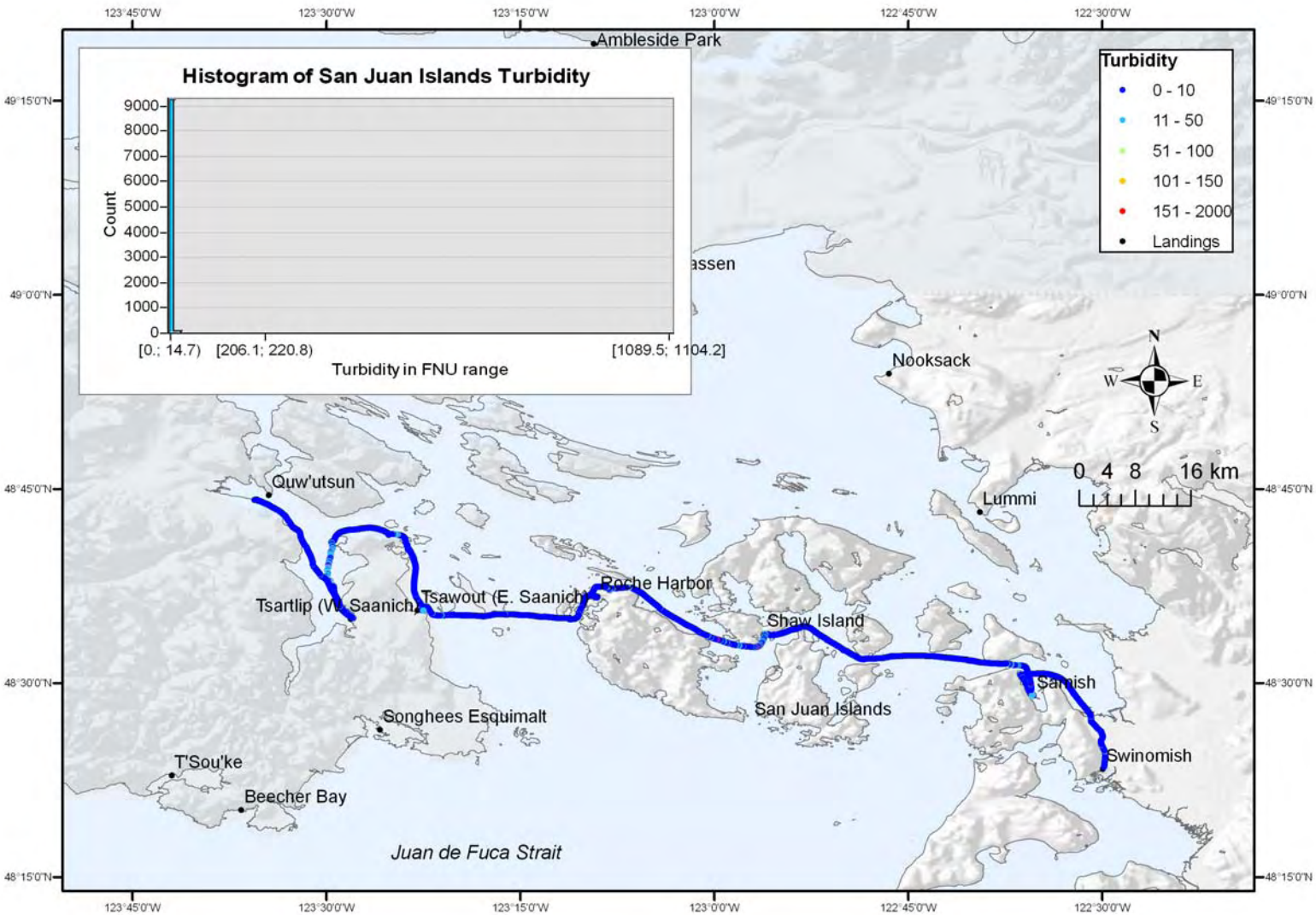


**Figure 4. Turbidity recorded along the San Juan Island track from July 22 to 28, 2008 including histogram of count of readings per turbidity.**

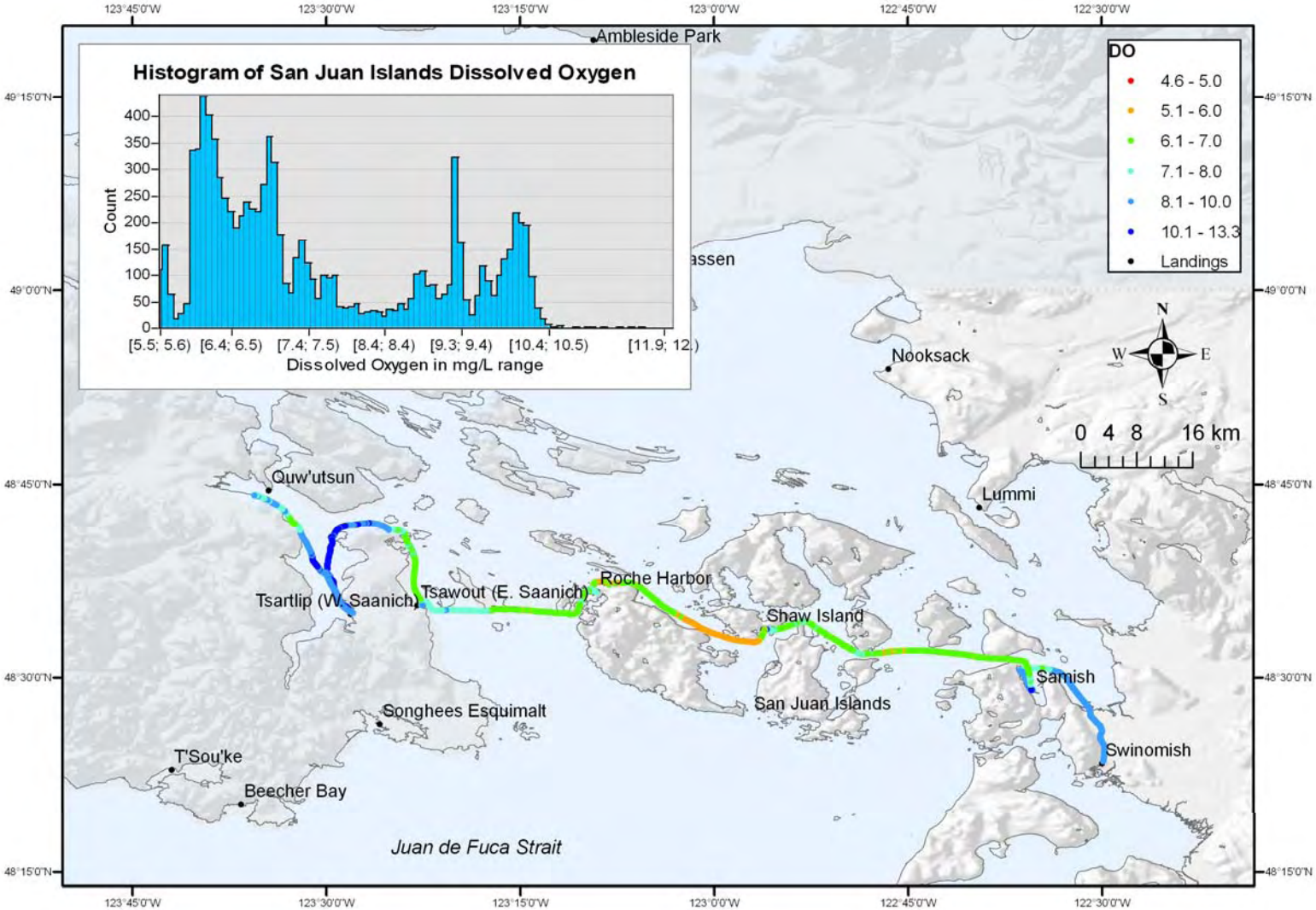


**Figure 5. Dissolved oxygen recorded along the San Juan Island track from July 22 to 28, 2008 including histogram of count of readings per dissolved oxygen.**

## Fraser River

The 2008 Tribal Journey was the first Journey for the Stolo People. With their new canoe, constructed by members of the pulling team, their travels started on the Fraser River. Stolo started their Journey July 24 and ended July 28, 2008. The first three days of Stolo track data were collected in the fresh waters of the Fraser River, and the last day of the data July 27 was collected in Georgia Strait marine waters. Data was not collected by Stolo for July 28, 2008. Stolo collected data along 55.5 miles of the Fraser River and 7.6 miles of the Georgia Strait. In total 3,367 data points were collected across 100% of the attempted distance. On day two of their travels, the GPS unit over heated and 292 points (9% of total data) of GPS coordinates had to be reconstructed for the water quality data. Weather conditions during the Stolo Journey consisted of hot inland air temperatures and calm winds. For the purposes of this report only the first three days of the Stolo journey down the Fraser River will be considered. The results are shown in Figures 19-23.

Surface water temperatures along the Fraser River averaged to 17.56°C (Appendix V). A maximum temperature of 19.89°C and a minimum of 16.98°C were recorded over the three day sampling period. The highest temperatures were generally recorded while the canoe was traveling close to the shore line in the shallow areas. Of the 3,367 data points collected 90, or 2.7% of the readings, were greater than 19°C, and 229 or 6.8% of the readings were greater than 18°C. In fresh waters, 16°C is the "Core Summer Salmonid Habitat" and 17.5°C is the upper limit for "Salmon Rearing and Migration" according to Washington State water quality code (WAC 173-201A-200). Surface water temperature results for the Fraser River were higher than the optimal limits for healthy salmonid habitat during summer months; no readings were below the established maximum limit of 16°C over the three day sampling period.

Salinity levels in the Fraser River were consistent with fresh water bodies, displaying an average salinity of 0.05, and a maximum of 0.09 and a minimum of 0.01. The pH levels of the surface waters of the Fraser River were ranged through the Journey. The median pH of Fraser River was 7.94, with a maximum of 8.18 and a minimum of 6.39. As with the elevated temperatures, low pH levels were generally associated with the shallow banks of the Fraser.

Turbidity levels were higher for the Fraser River than for any of the marine waters on average. Visually the water had a chalky quality. The average and median turbidity result for the three day journey was 46.23 FNU and 25.7 FNU respectively, with a maximum of 1310 FNU and a minimum of 3.2 FNU. The standard deviations for each of the travel days were higher than the average readings. It is very apparent when traveling out the Fraser Delta into the marine waters of the Georgia Strait how much more turbid the river water is than in the strait. The Fraser River must be a significant source of sediments to the regional nearshore environment.

The constantly moving waters of the Fraser River held exceptionally high surface water dissolved oxygen levels. The average track dissolved oxygen result was 9.88 mg/L, with a maximum of 10.15 mg/L and a minimum of 8.86 mg/L. Surface dissolved oxygen levels for the Fraser River were optimal, despite the elevated water and air temperatures recorded over the three sampling days.

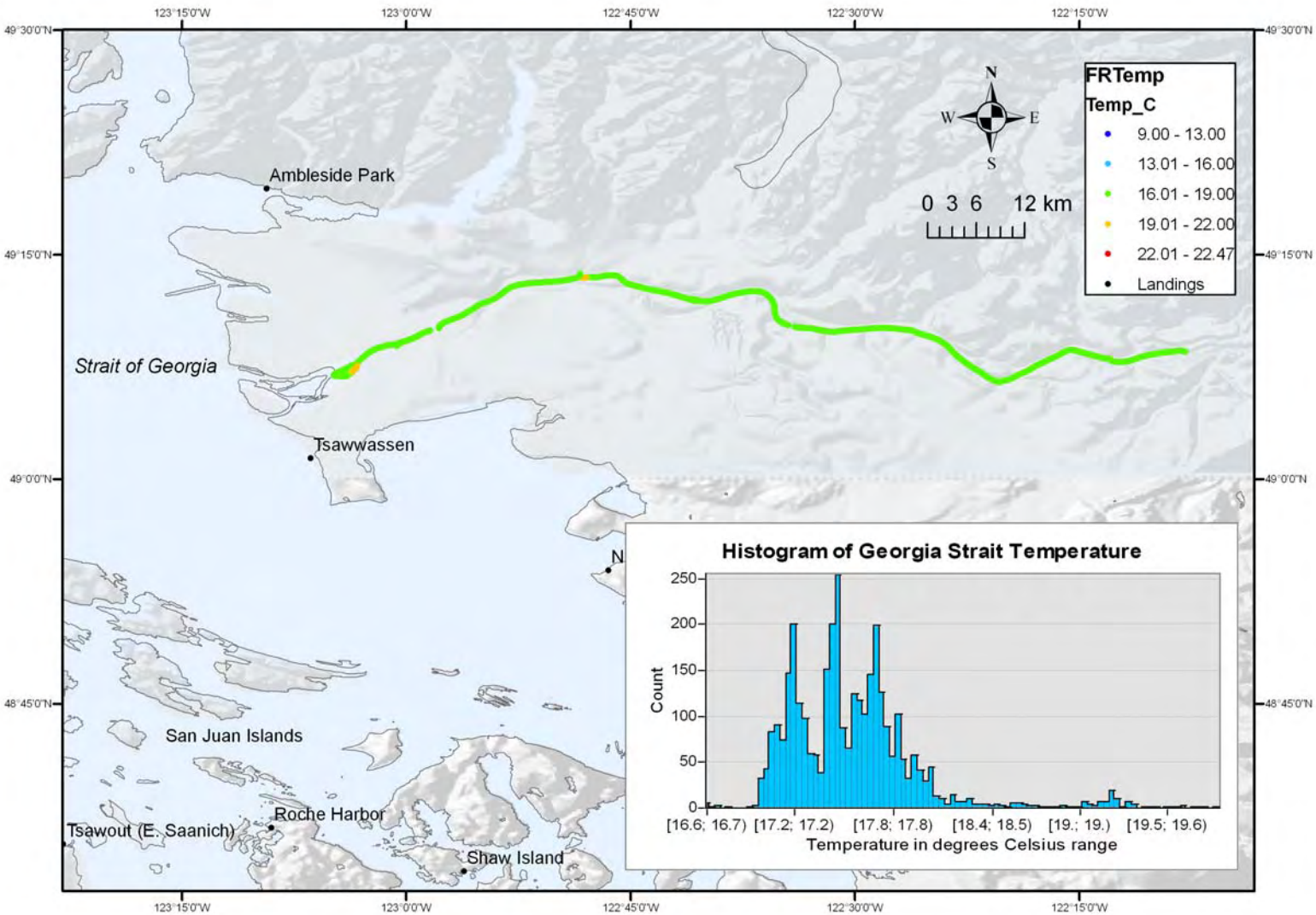


**Figure 6. Temperature recorded along the Fraser River track from July 24 to 26, 2008 including histogram of count of readings per temperature.**

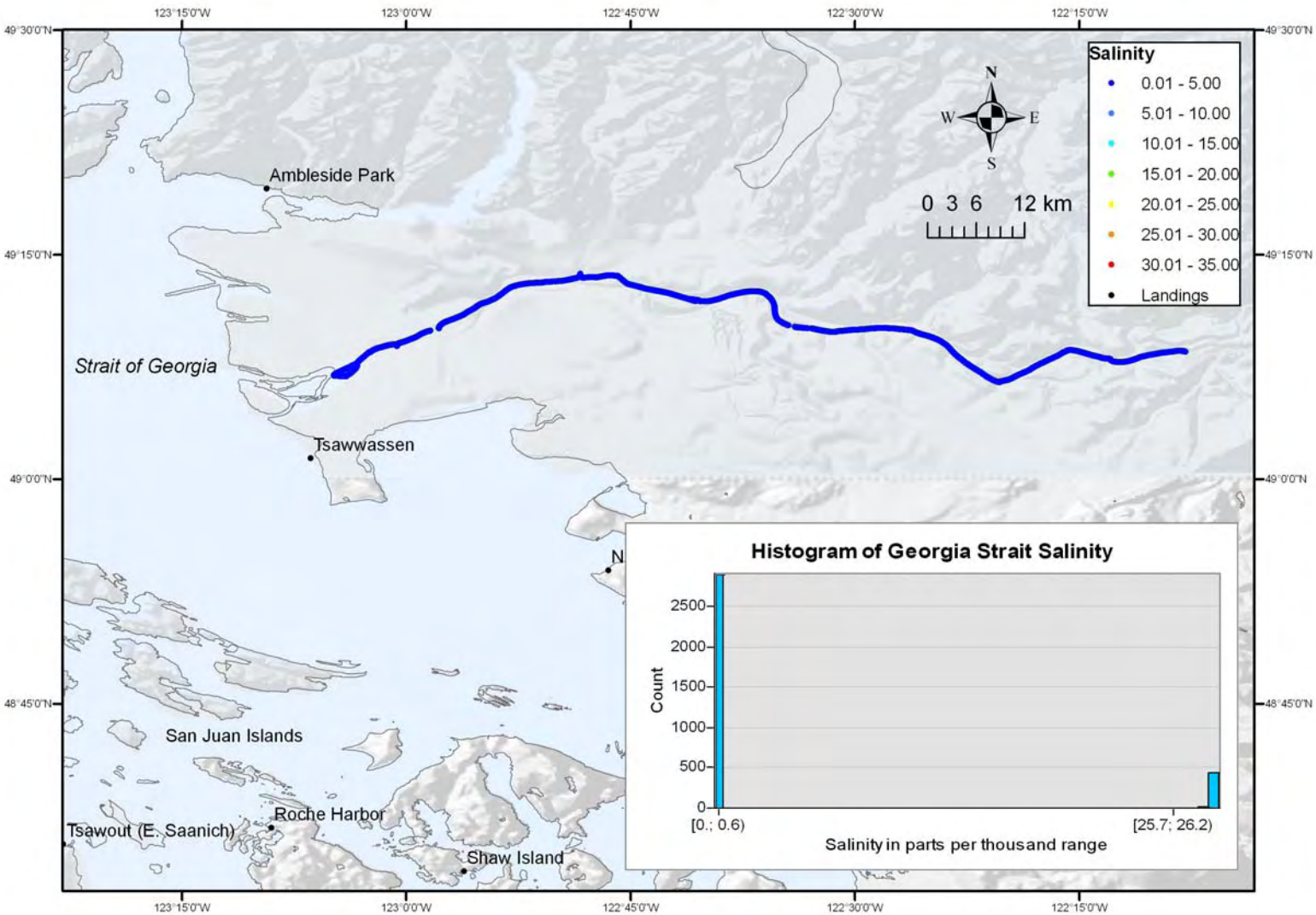


**Figure 7. Salinity recorded along the Fraser River track from July 24 to 26, 2008 including histogram of count of readings per salinity.**

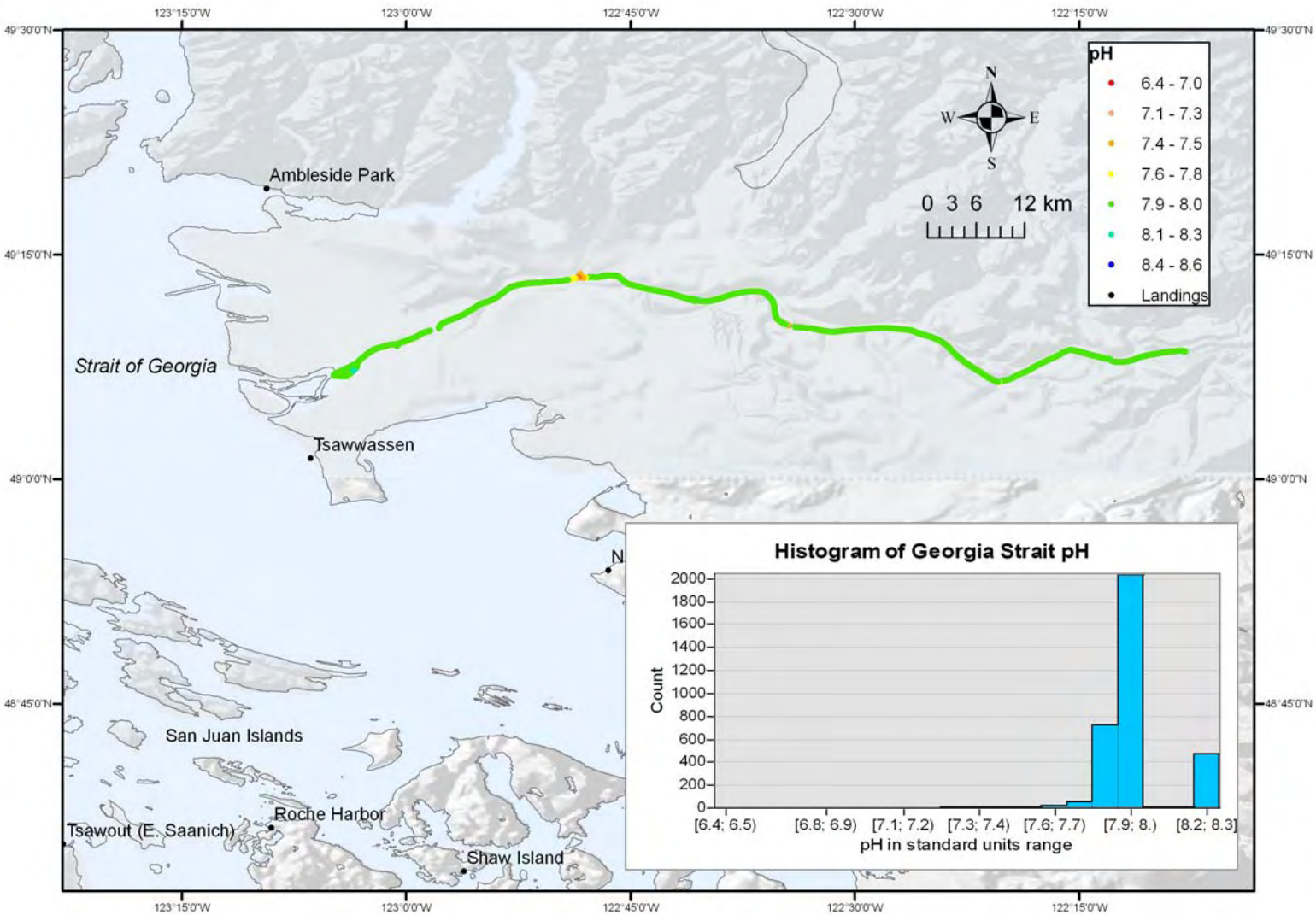


**Figure 8. pH recorded along the Fraser River track from July 24 to 26, 2008 including histogram of count of readings per pH.**

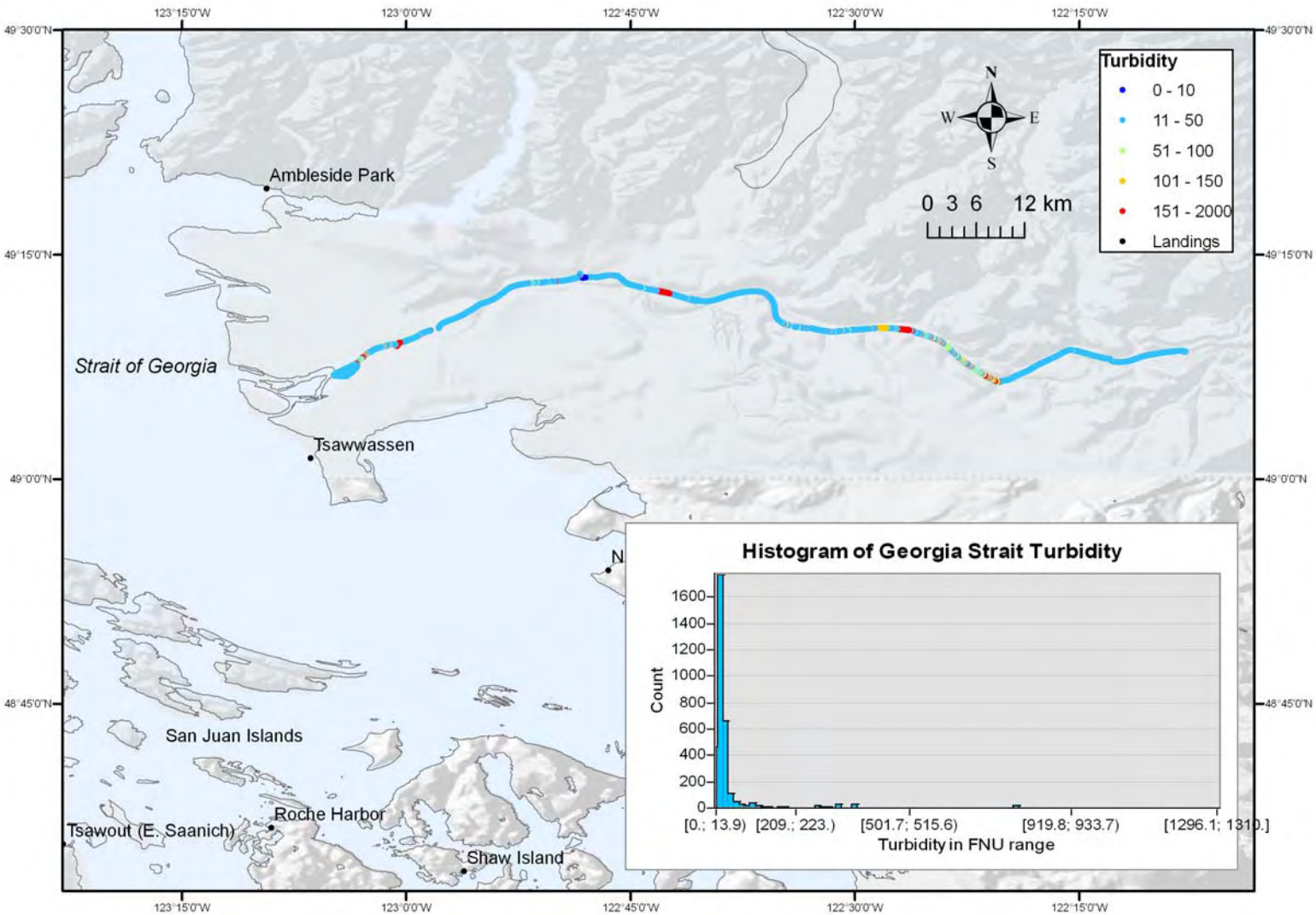


**Figure 9. Turbidity recorded along the Fraser River track from July 24 to 26, 2008 including histogram of count of readings per turbidity.**

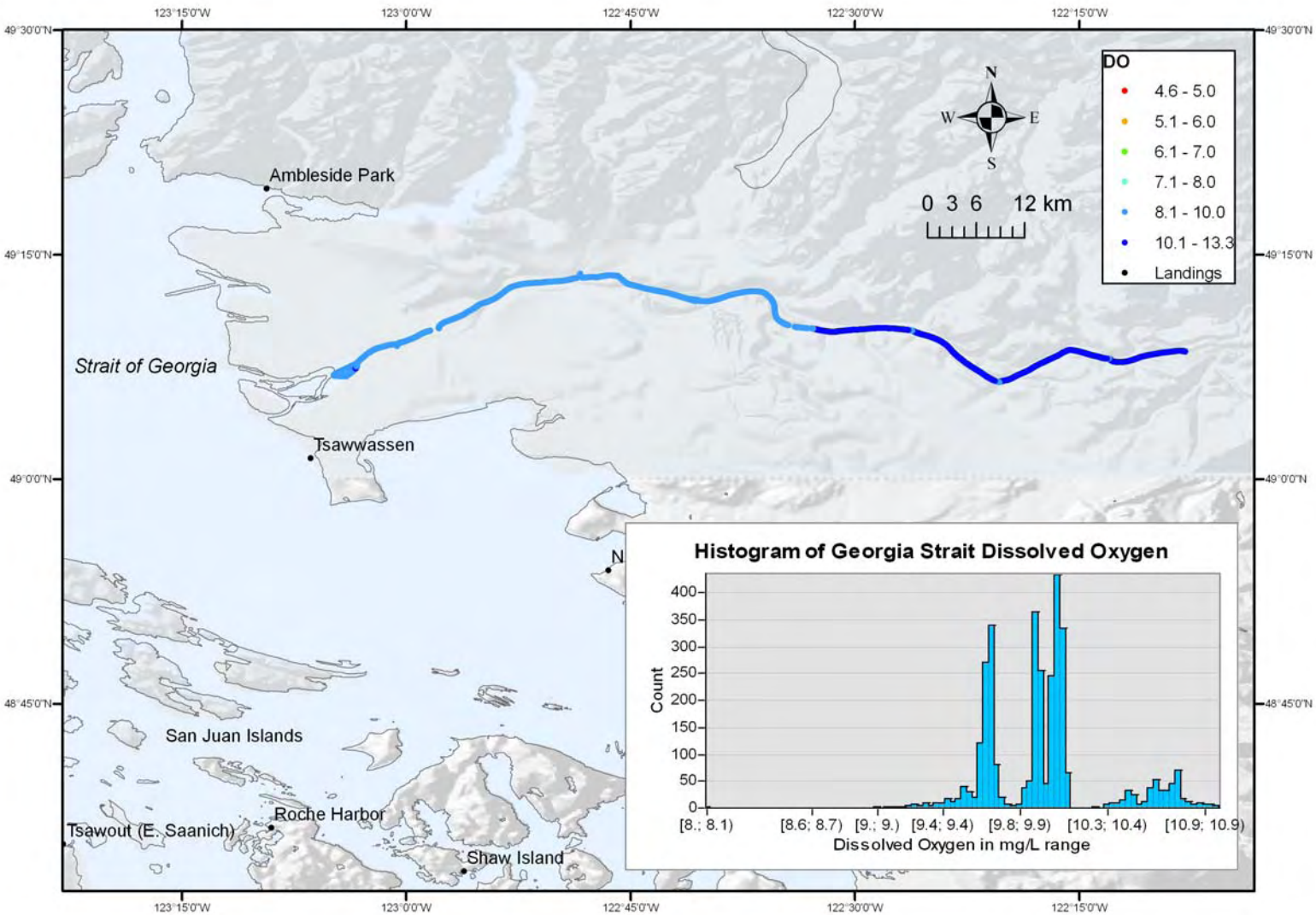


**Figure 10. Dissolved oxygen recorded along the Fraser River track from July 24 to 26, 2008 including histogram of count of readings per dissolved oxygen.**

## Georgia Strait

The Georgia Strait was monitored by the Homalco Nation during the 2008 Tribal Journey. Homalco left their home territory in Campbell River, British Columbia on July 23, 2008 and landed in Quw'utsun, British Columbia on July 28, 2008. Over the six days Homalco traveled 142 miles (or 230 kilometers) and collected 8,704 data points. Unfortunately Homalco experienced more technical problems during the Journey than any other track and data was collected along only 27% of the track. Latitude and Longitude points were reconstructed for portions of the YSI data that experienced GPS malfunction. For this analysis 8704 data points will be considered. The results are displayed in Figures 24-28.

An added difficulty for Homalco along the Journey was that weather conditions were not always favorable. High winds and swift currents forced the Canoe Family to decide to stop pulling on certain days. High seas made traveling the waters of the Georgia Strait dangerous for the experienced and inexperienced pullers alike.

Temperatures recorded along the Georgia Strait track were fairly high, even for the summer season. The average surface water temperature for the track was 16.91°C (good water quality standard), with a maximum recorded temperature of 22.47°C and a minimum temperature of 9.93°C (Appendix VI). Of the 8,704 temperature data points collected, 39% of the readings were above 18°C and 81% of the readings were above 16°C, the good water quality standard maximum for surface water temperatures.

The average salinity for the Georgia Strait over the course of the Journey was 25.58, with a maximum of 30.07 and a minimum of 9.93. The minimum readings for all of the days indicate that Homalco pulled past a significant fresh water source to the nearshore environment at least once per day.

The pH results for Georgia Strait were consistently higher than the other tracks along the Journey in 2008. The median pH for the Georgia Strait track was 8.26, with a maximum of 8.53 and a minimum of 7.72 pH units. Only 31 of the 8,704 pH samples resulted in readings that exceeded 8.5 pH units, most of these readings occurred on July 27. It is thought that pH readings above 8.5 decrease the ability for ecosystem processes to function effectively.

Over the course of the six day journey, turbidity levels averaged quite low. The average track turbidity for surface waters of the Georgia Strait was 6.56 FNU and the median value was 0.0 FNU, with a maximum of 1046 FNU and a minimum of 0 FNU. July 24 had the lowest turbidity levels of all the days recorded for the Journey with an average of 0.02 FNU and a maximum reading of 4.2 FNU.

Dissolved oxygen levels in the Georgia Strait were generally of extraordinary quality during the period between July 23 and July 28, 2008. The average track dissolved oxygen was 8.86 mg/L with a maximum of 13.17 mg/L and a minimum of 5.49 mg/L. Of 8,704 dissolved oxygen data points 3% fell below 6.0 mg/L, 12% fell below 7.0 mg/L, and no samples fell below 5.0 mg/L. Strong winds and currents during the sampling period could have kept dissolved oxygen levels within optimal ranges.

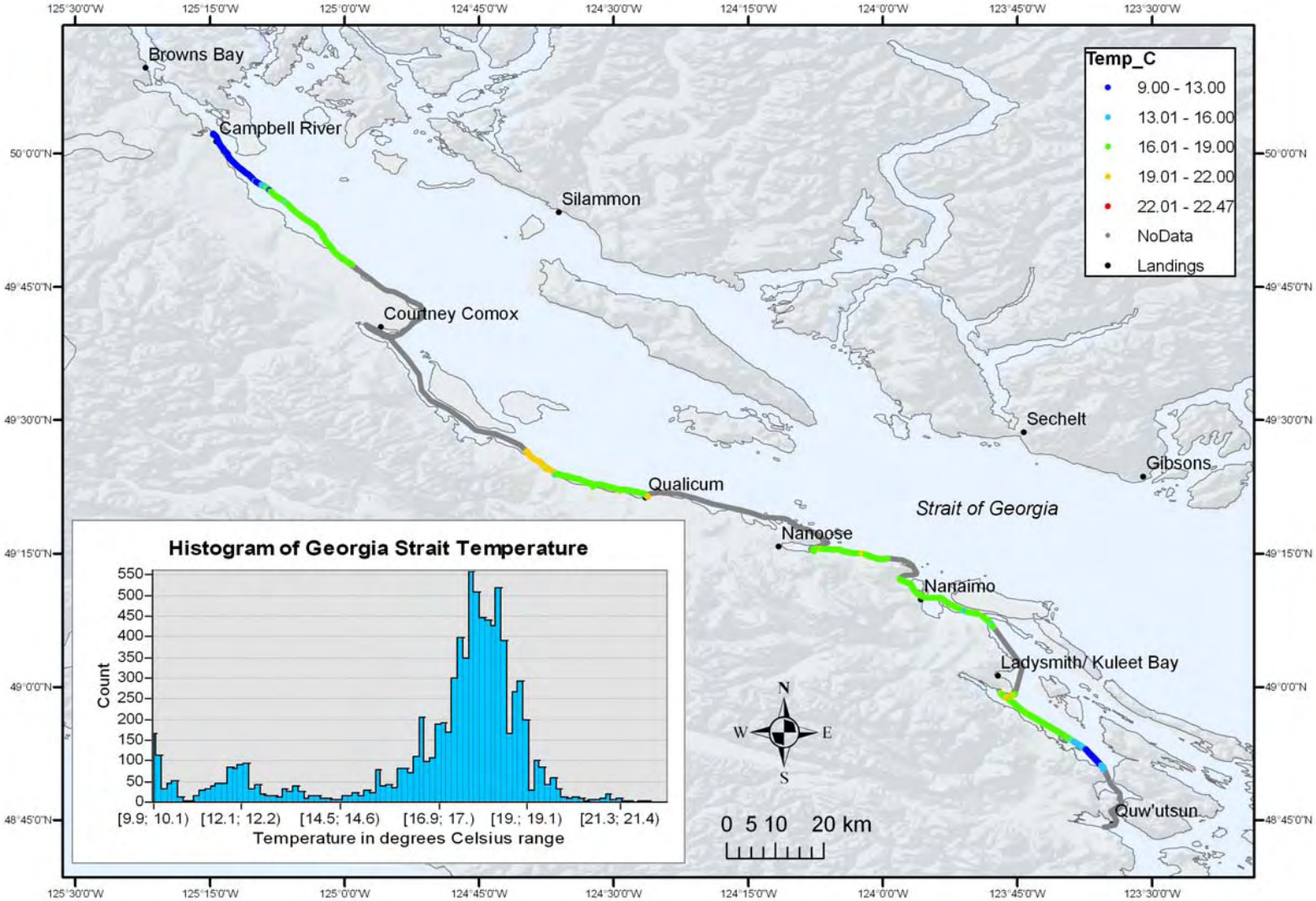


**Figure 1. Temperature recorded along the Georgia Strait track from July 23 to 28, 2008 including histogram of count of readings per temperature.**

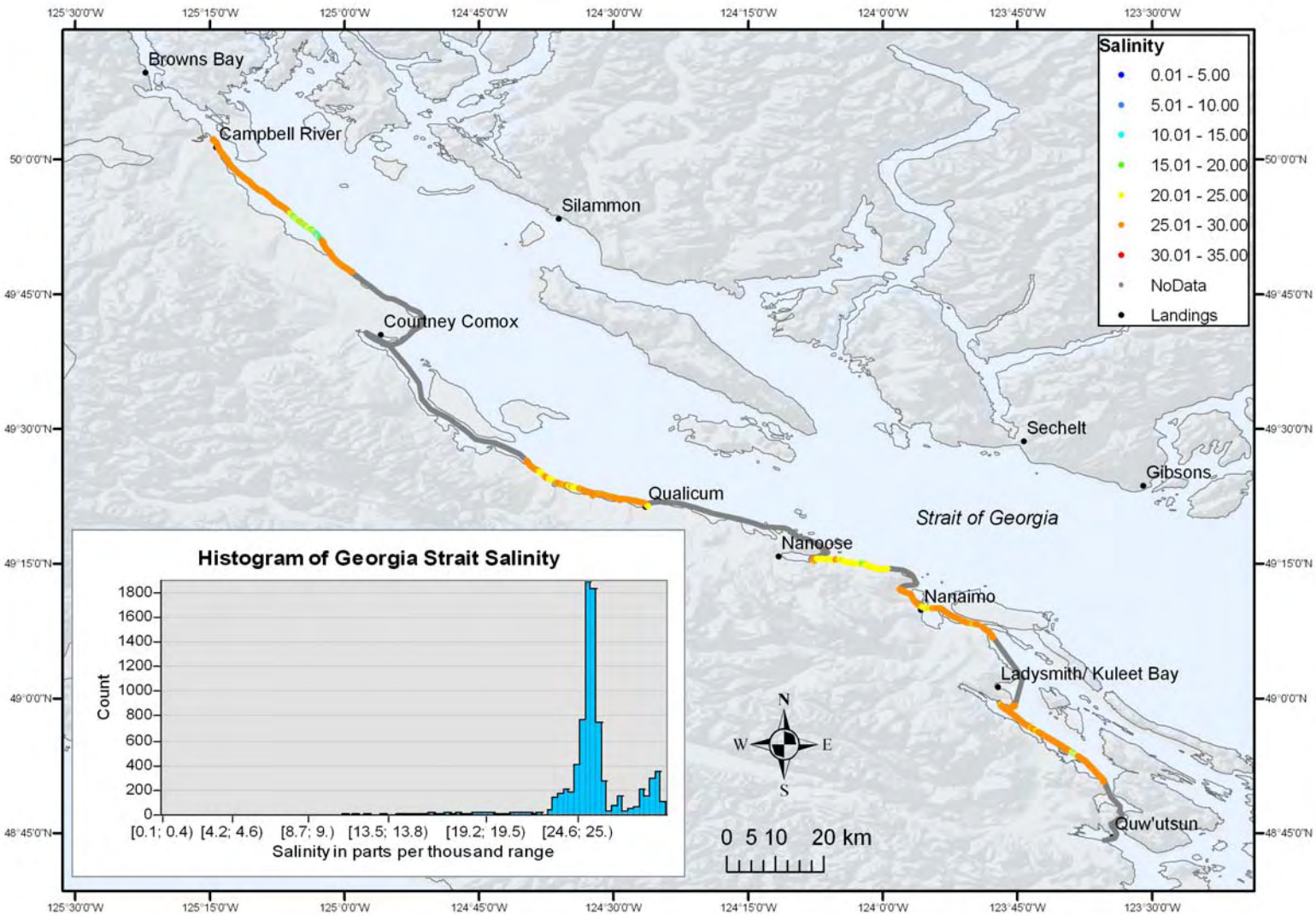


**Figure 2. Salinity recorded along the Georgia Strait track from July 23 to 28, 2008 including histogram of count of readings per salinity.**

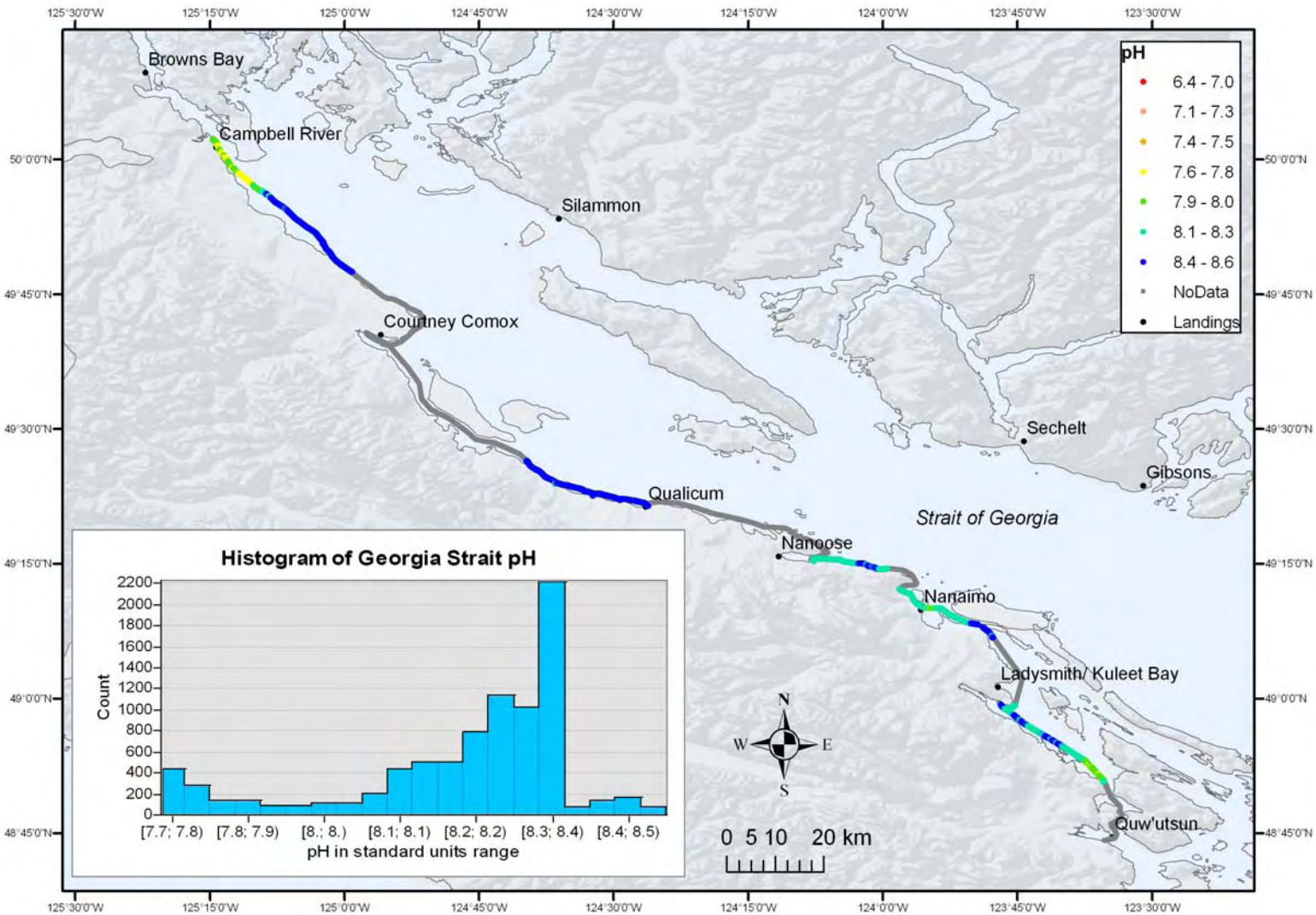


**Figure 3. pH recorded along the Georgia Strait track from July 23 to 28, 2008 including histogram of count of readings per pH.**

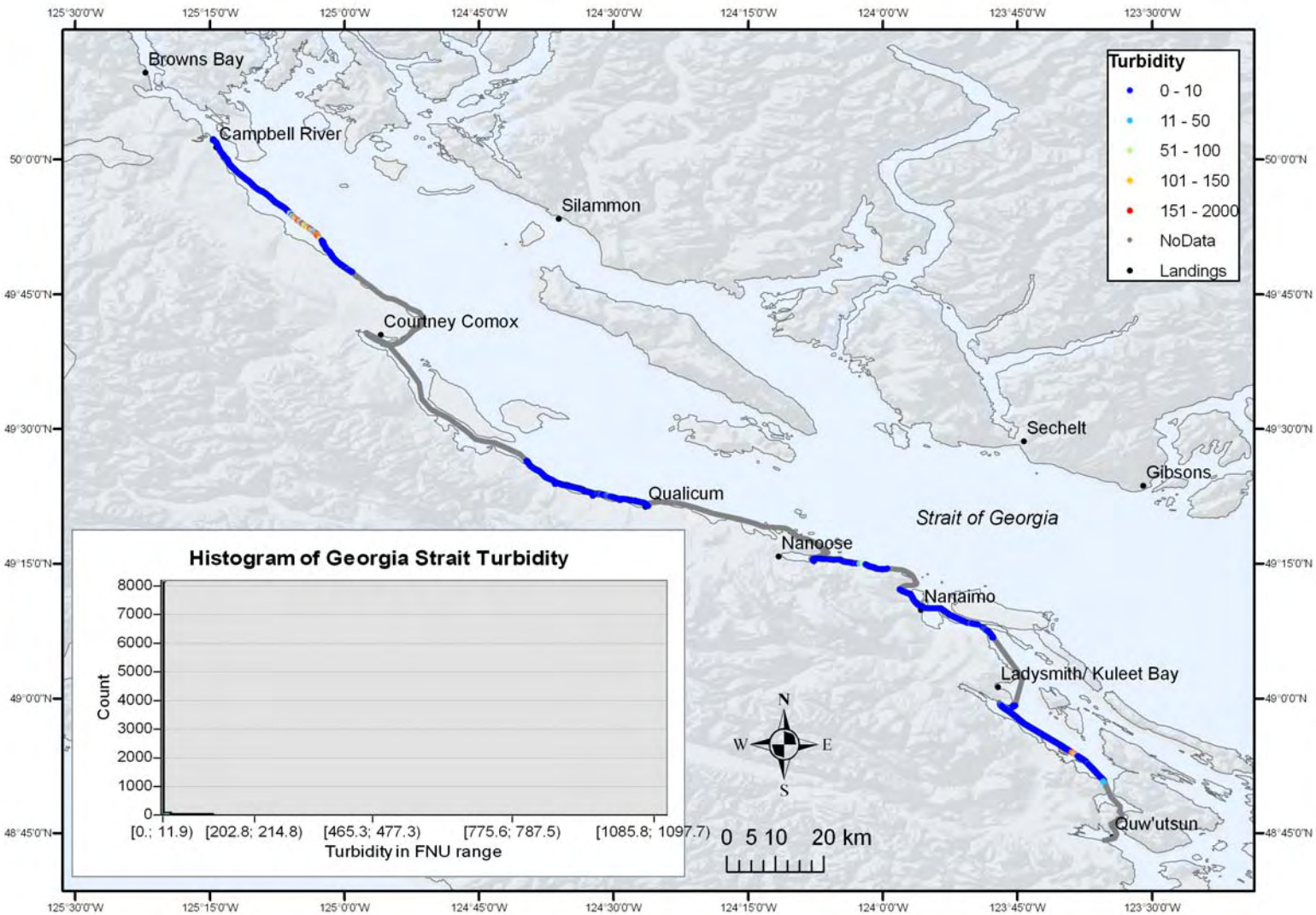


**Figure 4. Turbidity recorded along the Georgia Strait track from July 23 to 28, 2008 including histogram of count of readings per turbidity.**

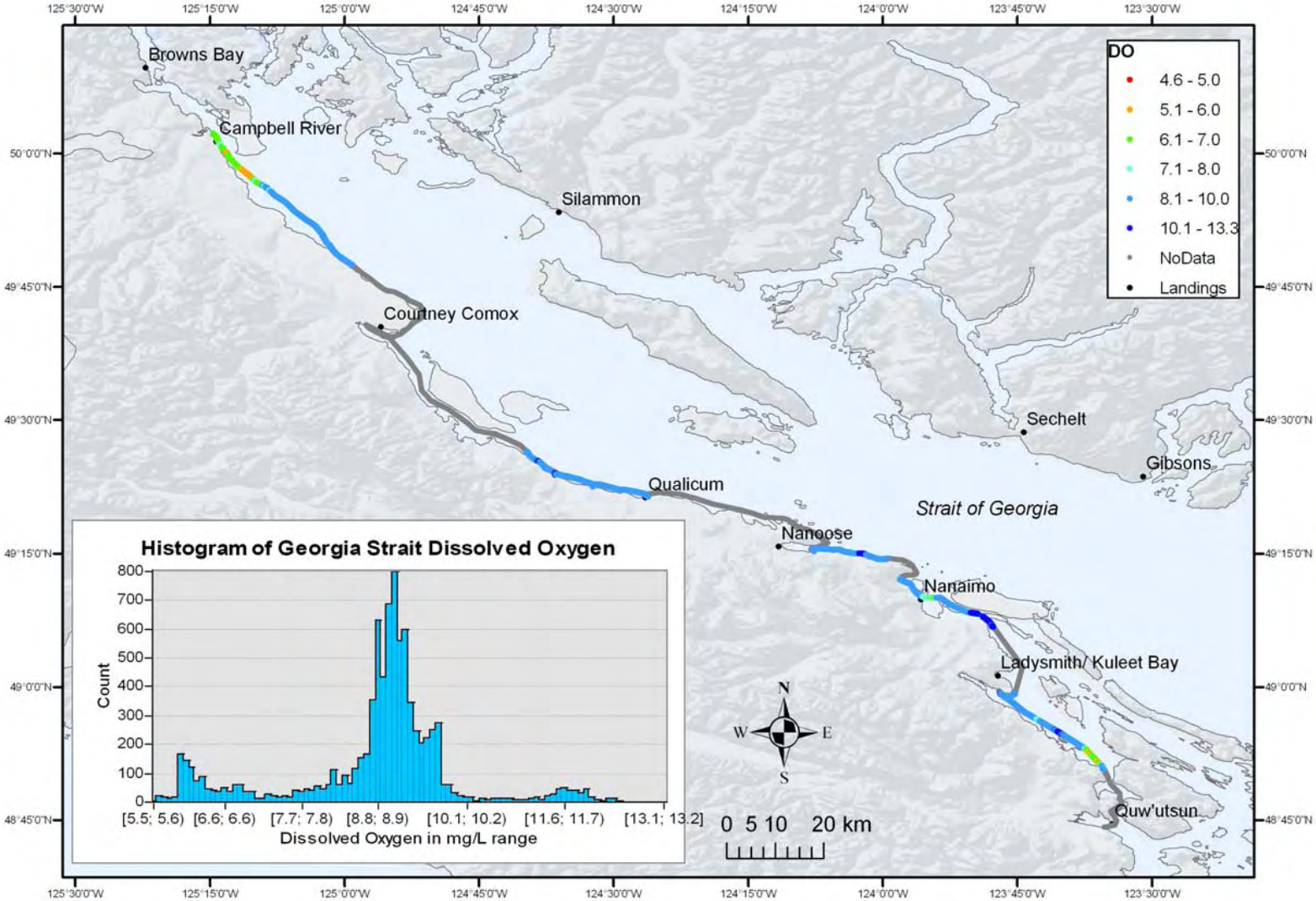


**Figure 5. Dissolved oxygen recorded along the Georgia Strait track from July 23 to 28, 2008 including histogram of count of readings per dissolved oxygen.**

## Discussion and Conclusions

Intensive water quality monitoring has been conducted around Puget Sound and the Georgia Straits since the 1980s, but coordinated, systematic surveys across the political border have not been previously conducted and integrated simultaneously until the 2008 TJWQP. The monumental data collection effort was made possible by blending science and tradition and by the participation of canoe families and scientists. The Tribal Journey findings serve as a detailed examination of water quality properties across a vast region during the stressful conditions of middle to late summer when surface water temperatures are highest, fresh water runoff from streams is past peak and biological growth and decay are in full swing.

Comparisons between tracks show general patterns in water quality parameters between different basins. Temperatures were generally lower in the Straits of Juan de Fuca while some of the highest temperatures were found in the Fraser River, southern Hood Canal, and eastern Vancouver Island. Salinities were greatest in the southern Puget Sound and Straits of Juan de Fuca and significantly lower in Hood Canal and along the eastern side of Vancouver Island. The pH of surface waters was relatively consistent across the various marine water bodies but varied most along the San Juan Islands track. Generally, waters were quite clear with low turbidity across all of the basins. The Fraser River was an exception demonstrating high turbidities, despite the fact that the Tribal Journey occurred over a month later than the principal snow-melt peak discharge. Dissolved oxygen reached low levels that are recognized by USEPA and Environment Canada as threatening in several locations including Hood Canal and offshore of Victoria, BC and were likely lower at depth.. Overall measured physical properties across the marine water were good to excellent.

Although the general findings of the first TJWQP in 2008 found measured physical properties across the Salish Sea to be good, lacking widespread degradation of specific parameters, interesting and possible areas of concern were found in Hood Canal, Anacortes Bay (Washington) and along the Victoria/Saanich, BC coastline. In Hood Canal after several days of cool, cloudy conditions, surface temperatures of 20-21°C were observed as early as 8:30 in morning (Figure 29). Surface waters of 20-21°C (~71°F) are not common in the Salish Sea but do occur where circulation is low and after long hot summer days. Although these temperatures were observed in Hood Canal early in the morning after several days of gloomy cool weather, it is likely that temperatures there get significantly higher after several sunny days and limited tidal exchange (for example during neap tides) and would subsequently affect plant and animal growth, restrict salmon distribution, and aid algal blooms.

**Figure 6. High temperatures recorded in Hood Canal in the early morning after several days of cloudy cool conditions.**

Shoreline structures can alter water quality. For example, in Fidalgo Bay reduced dissolved oxygen in coastal waters appeared to be associated with Marchs Point jetties (Figure 30). These values were observed during the later stages of slack tide and in the early stages of an incoming (flooding) tide, suggesting that waters emanating from Marchs Point could have an impact on a larger area of Anacortes Bay than merely inside the jetties. Dissolved oxygen levels within the jetties and their impact to organisms throughout Fidalgo Bay remain uncertain.

**Figure 7. Low dissolved oxygen readings may be associated with shoreline structures (e.g. man made embayments).**

Low dissolved oxygen was measured offshore of Victoria where the waters are generally thought to be well mixed (Figure 31). In fact, dissolved oxygen was lower in the vicinity of Oak Harbor than in the more urbanized and industrial section of Victoria Harbor and Esquimalt with an abrupt transition coinciding with the geomorphology of the coast.

**Figure 8. Low dissolved levels recorded offshore of Victoria B.C.**

Lower dissolved oxygen was observed east of Saanich Peninsula where mixing is greater than within Saanich Inlet (Figure 32). This is surprising and may be related to impaired water offshore of Victoria and Oak Harbor that would have been advected northward during the flooding tide when measurements were made.

**Figure 9. Low dissolved oxygen levels recorded offshore of East Saanich B.C.**

## Blending Science and Tradition

Along the Tribal Journey stories were shared between the Elders, the Youth, the Skippers and the Pullers. For some people the Tribal Journey is a time of healing, for others it is a way to reconnect with long lost relatives, for all it is a way to maintain tradition. With the introduction of the TJWQP, there is an added dialogue: the status of the environment. The Project has created an excellent opportunity for a concerned group of people, who are not necessarily scientists, to play a key role in a research effort as well as re-affirm the Coast Salish people's role as stewards of the environment.

With the success of the first TJWQP the Coast Salish People have made a significant contribution towards monitoring the waters of the Salish Sea. The outcomes of the Project will support the Coast Salish Nation's effort to address the environmental impacts. As the aboriginal inhabitants of the Salish Sea Ecosystem, Coast Salish are responsible for the well being and health of their ecosystem and communities and to share their understanding and

vision for the Salish Sea. Coast Salish has an important and leading role in helping to manage their communities today and into the future. The project acknowledges this role and encourages all Coast Salish people to actively participate and learn more about their traditional territory, the Salish Sea.

Degradation of water quality has caused hardship in the fishing and shellfish activities of the Coast Salish people. Culturally and economically, these are the core resources that define Coast Salish Communities. These environmental issues are central to the families and relatives on both sides of the border. We now have such an opportunity as this project provides a Coast Salish Science tool and the derived information that can be shared with the world. We know these environmental issues cannot be addressed individually or be resolved with only local policy and actions, but rather this is an ecosystem that needs to be addressed at a larger scale. The TJWQP is building strength by solidifying the scientific foundation to gather data and provide information for a structured policy dialogue process. Data and findings will be disseminated through the Coast Salish Gathering, to share the information with federal agencies and other interested parties. An open dialogue between the Coast Salish Gathering leadership and federal representatives will strengthen the local effort to provide a safe and healthy home for Coast Salish people for today and tomorrow. This is the common goal on a local and regional basis for the Coast Salish Nation.

## Recommendations and Future Directions

The strength of the water quality study lies in gathering information over multiple years/decades to identify trends and persistent impacts owing to human activities and expected climate change. Water quality conditions across the Salish Sea during the period between July 15 and July 28, 2008 were generally good to fair. Areas such as Hood Canal, the waters off of the Saanich Peninsula, and open water areas between the San Juan Islands showed signs of depressed dissolved oxygen levels. The Fraser River surface water temperatures were surprisingly high and turbid.

Planning is underway to secure funding and support to repeat the surveys during the 2009 Tribal Journey to Suquamish and into the future. We are exploring the possibility of adding additional routes along the Olympic Peninsula and West Vancouver Island to monitor oceanographic conditions in the Pacific that influence the Salish Sea from the west, especially as new studies have shown increasing ocean acidification and expanding oxygen depleted zones off of the Oregon and Washington Coasts. Other activities being planned are to collect time-series information on water quality to place the spatial measurements from the Journey into context. Additional activities include engaging the many support vessels to conduct complementary studies such as profiling water quality with depth and collect water samples and plankton tows for laboratory analyses to examine the vertical structure of the Salish Sea and nutrient loading and algal blooms and their affects on the food web.

This information is essential for the Coast Salish Nations to develop policy and implement resource management the Salish Sea Ecosystem. It is the ultimate goal of the TJWQP coordinators that the TJWQP becomes a sustainable Coast Salish project and that Coast Salish build the capacity to administer and expand the project to suit their needs. Ideally members of Canoe Families from around the Salish Sea will take the Project forward for the greater need of the Coast Salish Peoples.

## Acknowledgements

The 2008 Tribal Journey Water Quality Study was funded by the Northwest Straits Commission, the Swinomish Tribe, Potlatch Fund, and the U.S. Geological Survey and supported by Coast Salish Chiefs, Chairmen, Elders, and Canoe Skippers, the U.S. EPA, Environment Canada, and Parks Canada. We are grateful to the Squaxin Island Tribe, Homalco Nation, Stolo People, and the Swinomish Canoe Families and are especially thankful for the dedicated efforts of the water quality technicians who supported them. We would also like to thank Elissa Fjellman and Eric Haskins of the Swinomish GIS team for all of their help. We thank Ray Julich and Andrew Stevens of USGS for technical assistance in data visualization. Last but not least we would like to thank Jennifer LaVista, Don Becker, and Susan Marcus for all of their communications assistance.

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# Appendices

**Appendix I:** YSI 6920 V2-2 Sensor specifications including units, range, resolution, and accuracy. Units include milligrams per liter (mg/L), percent (%), Formazin Nephelometric Units (FNU), millisemans per centimeter (mS/cm), parts per thousand (ppt), degrees Celsius (°C), pH standard units, millivolts (mV), and meters (m).

| YSI Sensor | Units | Range | Resolution | Accuracy |
|---|---|---|---|---|
| ROX Optical Dissolved Oxygen | mg/L | 0 to 50 mg/L | 0.01 mg/L | 0 to 20 mg/L: ± 0.1 mg/L or 1% of reading |
| Turbidity 6136 Sensor[1] | FNU | 0 to 1,000 FNU | 0.1 FNU | ±2% of reading or 0.3 FNU, whichever is greater |
| Conductivity 6560 Sensor | mS/cm | 0 to 100 mS/cm | 0.001 to 0.1 mS/cm | ±0.5% of reading + 0.001 mS/cm |
| Salinity | ppt | 0 to 70 ppt | 0.01 ppt | ±1% of reading or 0.1 ppt, whichever is greater |
| Temperature 6560 Sensor | °C | -5 to +50°C | 0.01°C | ±0.15°C |
| pH 6561 Sensor | units | 0 to 14 units | 0.01 units | ±0.2 units |
| Oxidation Reduction Potential | mV | -999 to +999 mV | 0.1 mV | ±20 mV |
| Depth - Shallow | m | 0 to 9.1 m | 0.001m | ±0.02m |

1. The United States Geological Survey methods for reporting turbidity data collected with near-infrared turbidimeters following ISO 7027 protocols is reported as Formazin Nephelometric Units (FNU). More information can be found in the USGS National Field Manual (http://water.usgs.gov/owq/FieldManual/Chapter6/6.8.pdf)

**Appendix II:** Water quality statistics from the Puget Sound track. Average, median, maximum, minimum, standard deviations (StdDev), and number of observations (n) for temperature in degrees Celsius (°C), salinity in parts per thousand (ppt), pH in standard pH units, turbidity in Formazin Nephelometric Units (FNU), and dissolved oxygen in milligrams per liter (mg/L). Data was measured between July 15, 2008 and July 28, 2008. Instrument audit failed for turbidity on July 15, 2008, indicated by the data quality error code (DQE).

| **Puget Sound** | July 15 | July 16 | July 17 | July 19 | July 20 | July 21 | July 22 | July 23 | July 25 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| n* | 1495 | 1015 | 2391 | 1206 | 2325 | 901 | 1440 | 1787 | 1274 | 1739 | 2010 | 1103 | 18686 |

| **Temperature (°C)** | July 15 | July 16 | July 17 | July 19 | July 20 | July 21 | July 22 | July 23 | July 25 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 14.59 | 12.99 | 14.46 | 14.47 | 13.73 | 12.65 | 12.25 | 10.85 | 10.73 | 11.50 | 15.39 | 14.99 | 13.30 |
| Maximum | 17.87 | 15.16 | 16.05 | 18.04 | 16.19 | 13.84 | 16.21 | 14.17 | 11.81 | 14.46 | 19.29 | 18.35 | 19.29 |
| Minimum | 12.66 | 11.86 | 13.06 | 11.97 | 11.59 | 11.57 | 10.41 | 10.30 | 9.72 | 9.00 | 11.48 | 12.35 | 9.00 |
| StdDev | 0.98 | 0.70 | 0.43 | 0.70 | 0.92 | 0.56 | 1.28 | 0.46 | 0.34 | 1.10 | 2.44 | 1.65 | 1.96 |

| **Salinity (ppt)** | July 15 | July 16 | July 17 | July 19 | July 20 | July 21 | July 22 | July 23 | July 25 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 29.40 | 31.58 | 25.93 | 29.85 | 30.45 | 29.56 | 30.64 | 30.73 | 28.65 | 30.00 | 27.95 | 27.96 | 29.23 |
| Maximum | 30.34 | 32.51 | 28.63 | 31.17 | 32.05 | 30.00 | 31.02 | 31.35 | 31.69 | 31.87 | 29.59 | 29.02 | 32.51 |
| Minimum | 14.01 | 18.49 | 11.71 | 25.17 | 20.55 | 25.04 | 27.62 | 21.97 | 5.66 | 9.25 | 6.82 | 19.10 | 5.66 |
| StdDev | 1.18 | 1.53 | 3.97 | 0.70 | 1.06 | 0.34 | 0.22 | 0.60 | 4.61 | 1.05 | 1.25 | 0.80 | 2.62 |

| **pH** | July 15 | July 16 | July 17 | July 19 | July 20 | July 21 | July 22 | July 23 | July 25 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Median | 8.12 | 8.10 | 8.23 | 8.13 | 8.08 | 8.00 | 7.95 | 7.79 | 7.77 | 7.90 | 8.20 | 8.19 | 8.06 |
| Maximum | 8.35 | 8.32 | 8.32 | 8.55 | 8.35 | 8.33 | 8.37 | 8.06 | 7.83 | 8.05 | 8.29 | 8.33 | 8.55 |
| Minimum | 7.94 | 7.66 | 7.26 | 7.91 | 7.55 | 7.77 | 7.34 | 7.53 | 7.51 | 7.64 | 7.81 | 7.82 | 7.26 |

| **Turbidity (FNU)** | July 15 | July 16 | July 17 | July 19 | July 20 | July 21 | July 22 | July 23 | July 25 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | DQE | 16.52 | 5.19 | 31.05 | 3.88 | 3.25 | 2.60 | 6.06 | 93.19 | 2.79 | 0.26 | 6.86 | 13.08 |
| Median | DQE | 0.00 | 1.80 | 0.00 | 0.00 | 0.40 | 0.20 | 0.80 | 1.30 | 0.00 | 0.00 | 0.20 | 0.20 |
| Maximum | DQE | 1413.40 | 213.60 | 1983.90 | 745.60 | 50.10 | 381.20 | 453.70 | 1688.30 | 403.20 | 21.30 | 356.10 | 1983.90 |
| Minimum | DQE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| StdDev | DQE | 83.67 | 8.94 | 188.04 | 18.70 | 5.74 | 12.34 | 27.50 | 236.72 | 15.75 | 0.96 | 15.95 | 88.35 |

**Appendix II (Continued):** Water quality statistics from the Puget Sound track. Average, median, maximum, minimum, standard deviations (StdDev), and number of observations (n) for temperature in degrees Celsius (°C), salinity in parts per thousand (ppt), pH in standard pH units, turbidity in Formazin Nephelometric Units (FNU), and dissolved oxygen in milligrams per liter (mg/L). Data was measured between July 15, 2008 and July 28, 2008. Instrument audit failed for turbidity on July 15, 2008, indicated by the data quality error code (DQE).

| **Dissolved Oxygen (mg/L)** | July 15 | July 16 | July 17 | July 19 | July 20 | July 21 | July 22 | July 23 | July 25 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 10.54 | 10.00 | 10.78 | 9.57 | 8.95 | 8.67 | 8.52 | 7.23 | 7.00 | 6.98 | 9.13 | 9.00 | 8.90 |
| Maximum | 13.21 | 12.14 | 12.53 | 12.07 | 12.35 | 13.03 | 12.50 | 10.70 | 9.09 | 9.29 | 11.76 | 10.33 | 13.21 |
| Minimum | 7.25 | 8.64 | 7.89 | 7.90 | 7.29 | 7.40 | 6.15 | 6.55 | 5.77 | 4.64 | 6.38 | 6.63 | 4.64 |
| StdDev | 0.94 | 0.84 | 0.76 | 0.48 | 0.96 | 0.77 | 1.50 | 0.52 | 0.51 | 0.91 | 1.58 | 1.07 | 1.62 |

* 3118 n with reconstructed GPS coordinates

**Appendix III:** Water Quality Statistics from Hood Canal. Average, median, maximum, minimum, standard deviations (StdDev), and number of observations (n) for temperature in degrees Celsius (°C), salinity in parts per thousand (ppt), pH in standard pH units, turbidity in Formazin Nephelometric Units (FNU), and dissolved oxygen in milligrams per liter (mg/L). Data was measured between July 18, 2008 and July 20, 2008.

| **Hood Canal** | July 18 | July 19 | July 20 | Grand Total |
|---|---|---|---|---|
| n | 2086 | 1080 | 1504 | 4670 |

| **Temperature** | July 18 | July 19 | July 20 | Grand Total |
|---|---|---|---|---|
| Average (°C) | 19.52 | 18.85 | 16.12 | 18.27 |
| Maximum (°C) | 21.63 | 21.41 | 18.20 | 21.63 |
| Minimum (°C) | 16.85 | 14.64 | 14.55 | 14.55 |
| StdDev (°C) | 1.27 | 0.83 | 0.85 | 1.84 |

| **Salinity** | July 18 | July 19 | July 20 | Grand Total |
|---|---|---|---|---|
| Average (ppt) | 24.97 | 24.96 | 28.11 | 25.98 |
| Maximum (ppt) | 26.67 | 26.25 | 29.21 | 29.21 |
| Minimum (ppt) | 3.72 | 11.77 | 24.62 | 3.72 |
| StdDev (ppt) | 1.80 | 1.48 | 0.68 | 2.06 |

| **pH** | July 18 | July 19 | July 20 | Grand Total |
|---|---|---|---|---|
| Median | 8.25 | 8.29 | 8.29 | 8.26 |
| Maximum | 8.30 | 8.45 | 8.46 | 8.46 |
| Minimum | 7.82 | 8.19 | 8.19 | 7.82 |

| **Turbidity** | July 18 | July 19 | July 20 | Grand Total |
|---|---|---|---|---|
| Average (FNU) | 0.94 | 0.56 | 2.49 | 1.35 |
| Median (FNU) | 0.00 | 0.00 | 1.10 | 0.00 |
| Maximum (FNU) | 114.90 | 16.50 | 159.40 | 159.40 |
| Minimum (FNU) | 0.00 | 0.00 | 0.00 | 0.00 |
| StdDev (FNU) | 4.61 | 1.46 | 6.51 | 4.93 |

| **Dissolved Oxygen** | July 18 | July 19 | July 20 | Grand Total |
|---|---|---|---|---|
| Average (mg/L) | 9.07 | 10.03 | 10.70 | 9.81 |
| Maximum (mg/L) | 10.95 | 12.36 | 13.30 | 13.30 |
| Minimum (mg/L) | 5.83 | 9.21 | 9.80 | 5.83 |
| StdDev (mg/L) | 0.75 | 0.67 | 0.53 | 0.98 |

**Appendix IV:** Water Quality Statistics from San Juan Islands. Average, median, maximum, minimum, standard deviations (StdDev), and number of observations (n) for temperature in degrees Celsius (°C), salinity in parts per thousand (ppt), pH in standard pH units, turbidity in Formazin Nephelometric Units (FNU), and dissolved oxygen in milligrams per liter (mg/L). Data was measured between July 22, 2008 and July 28, 2008.

| **Temperature** | July 22 | July 23 | July 24 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|
| Average (°C) | 13.84 | 11.17 | 10.76 | 11.41 | 14.97 | 14.82 | 12.64 |
| Maximum (°C) | 15.41 | 12.93 | 12.67 | 13.27 | 19.09 | 17.07 | 19.09 |
| Minimum (°C) | 11.19 | 10.56 | 10.22 | 10.48 | 11.45 | 12.24 | 10.22 |
| StdDev (°C) | 0.65 | 0.44 | 0.38 | 0.64 | 2.50 | 1.67 | 2.18 |

| **Salinity** | July 22 | July 23 | July 24 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|
| Average (ppt) | 24.28 | 30.13 | 30.06 | 29.74 | 28.06 | 28.02 | 28.65 |
| Maximum (ppt) | 29.79 | 30.48 | 30.69 | 30.42 | 29.55 | 29.00 | 30.69 |
| Minimum (ppt) | 15.78 | 26.53 | 25.39 | 27.84 | 14.30 | 21.77 | 14.30 |
| StdDev (ppt) | 4.16 | 0.21 | 0.40 | 0.39 | 1.08 | 0.57 | 2.49 |

| **pH** | July 22 | July 23 | July 24 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|
| Median | 7.96 | 7.79 | 7.86 | 7.88 | 8.18 | 8.19 | 7.88 |
| Maximum | 8.21 | 8.10 | 8.01 | 8.11 | 8.38 | 8.31 | 8.38 |
| Minimum | 7.77 | 7.65 | 7.56 | 7.77 | 7.84 | 7.88 | 7.56 |

| **Turbidity** | July 22 | July 23 | July 24 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|
| Average (FNU) | 6.35 | 1.58 | 5.34 | 4.55 | 0.90 | 1.73 | 3.21 |
| Median (FNU) | 4.20 | 0.90 | 0.10 | 0.00 | 0.00 | 0.40 | 0.70 |
| Maximum (FNU) | 446.20 | 221.20 | 1104.20 | 259.40 | 137.90 | 200.10 | 1104.20 |
| Minimum (FNU) | 1.20 | 0.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| StdDev (FNU) | 19.24 | 4.85 | 45.11 | 19.16 | 4.64 | 6.64 | 20.93 |

| **Dissolved Oxygen** | July 22 | July 23 | July 24 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|
| Average (mg/L) | 8.94 | 6.57 | 6.22 | 6.92 | 8.69 | 8.88 | 7.55 |
| Maximum (mg/L) | 11.49 | 10.21 | 8.56 | 9.18 | 12.03 | 10.28 | 12.03 |
| Minimum (mg/L) | 6.32 | 5.95 | 5.54 | 5.98 | 6.18 | 6.62 | 5.54 |
| StdDev (mg/L) | 0.75 | 0.46 | 0.50 | 0.69 | 1.60 | 1.12 | 1.46 |

**Appendix V:** Water Quality Statistics from Fraser River. Average, maximum, minimum, standard deviations (StdDev), and number of observations (n) for temperature in degrees Celsius (°C), salinity in parts per thousand (ppt), pH in standard pH units, turbidity in Formazin Nephelometric Units (FNU), and dissolved oxygen in milligrams per liter (mg/L). Data was measured between July 24, 2008 and July 26, 2008.

| **Fraser River** | July 24 | July 25 | July 26 | Grand Total |
|---|---|---|---|---|
| n* | 1178 | 710 | 1002 | 2890 |

| **Temperature** | July 24 | July 25 | July 26 | Grand Total |
|---|---|---|---|---|
| Average (°C) | 17.26 | 17.88 | 17.70 | 17.56 |
| Maximum (°C) | 19.41 | 19.89 | 19.35 | 19.89 |
| Minimum (°C) | 16.98 | 17.62 | 17.38 | 16.98 |
| StdDev (°C) | 0.18 | 0.30 | 0.48 | 0.43 |

| **Salinity** | July 24 | July 25 | July 26 | Grand Total |
|---|---|---|---|---|
| Average(ppt) | 0.05 | 0.05 | 0.05 | 0.05 |
| Maximum (ppt) | 0.09 | 0.05 | 0.08 | 0.09 |
| Minimum (ppt) | 0.01 | 0.02 | 0.03 | 0.01 |
| StdDev (ppt) | 0.01 | 0.00 | 0.01 | 0.01 |

| **pH** | July 24 | July 25 | July 26 | Grand Total |
|---|---|---|---|---|
| Median | 7.97 | 7.95 | 7.90 | 7.94 |
| Maximum | 8.08 | 8.06 | 8.18 | 8.18 |
| Minimum | 7.52 | 6.93 | 6.39 | 6.39 |

| **Turbidity** | July 24 | July 25 | July 26 | Grand Total |
|---|---|---|---|---|
| Average (FNU) | 51.40 | 44.83 | 41.15 | 46.23 |
| Median (FNU) | 27.50 | 24.20 | 24.80 | 25.70 |
| Maximum (FNU) | 929.30 | 1310.00 | 577.20 | 1310.00 |
| Minimum (FNU) | 6.80 | 3.20 | 3.60 | 3.20 |
| StdDev (FNU) | 68.48 | 94.49 | 66.07 | 75.06 |

| **Dissolved Oxygen** | July 24 | July 25 | July 26 | Grand Total |
|---|---|---|---|---|
| Average (mg/L) | 10.06 | 9.93 | 9.65 | 9.88 |
| Maximum (mg/L) | 10.15 | 10.00 | 10.07 | 10.15 |
| Minimum (mg/L) | 9.01 | 9.03 | 8.86 | 8.86 |
| StdDev (mg/L) | 0.08 | 0.13 | 0.10 | 0.21 |

*292 n with reconstructed GPS coordinates

**Appendix VI:** Water Quality Statistics from Georgia Strait. Average, median, maximum, minimum, standard deviations (StdDev), and number of observations (n) for temperature in degrees Celsius (°C), salinity in parts per thousand (ppt), pH in standard pH units, turbidity in Formazin Nephelometric Units (FNU), and dissolved oxygen in milligrams per liter (mg/L). Data was measured between July 23, 2008 and July 28, 2008. Instrument audits failed for turbidity on July 23 and 24, 2008, indicated by the data quality error code (DQE).

| **Georgia Strait** | July 23 | July 24 | July 25 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|
| n* | 547 | 1566 | 1958 | 892 | 1312 | 2429 | 8704 |

| **Temperature** | July 23 | July 24 | July 25 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|
| Average (°C) | 14.77 | 19.03 | 18.39 | 18.12 | 17.49 | 16.46 | 16.91 |
| Maximum (°C) | 18.24 | 21.65 | 22.47 | 19.08 | 19.79 | 19.13 | 22.47 |
| Minimum (°C) | 9.93 | 16.89 | 13.13 | 17.46 | 13.85 | 10.98 | 9.93 |
| StdDev (°C) | 3.08 | 1.21 | 0.55 | 0.56 | 0.91 | 2.44 | 2.46 |

| **Salinity** | July 23 | July 24 | July 25 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|
| Average (ppt) | 25.85 | 25.37 | 25.21 | 23.95 | 25.69 | 26.19 | 25.58 |
| Maximum (ppt) | 29.89 | 26.42 | 26.24 | 25.28 | 27.63 | 30.07 | 30.07 |
| Minimum (ppt) | 0.09 | 19.46 | 3.70 | 17.60 | 24.00 | 9.07 | 0.09 |
| StdDev (ppt) | 4.21 | 1.01 | 1.51 | 1.26 | 0.49 | 2.37 | 2.58 |

| **pH** | July 23 | July 24 | July 25 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|
| Median | 8.30 | 8.00 | 8.33 | 8.24 | 8.16 | 8.21 | 8.26 |
| Max pH | 8.38 | 8.53 | 8.40 | 8.51 | 8.52 | 8.38 | 8.53 |
| Min pH | 7.72 | 8.29 | 7.94 | 8.07 | 7.75 | 7.73 | 7.72 |

| **Turbidity** | July 23 | July 24 | July 25 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|
| Average (FNU) | DQE | DQE | 1.21 | 6.16 | 1.50 | 12.89 | 6.56 |
| Median (FNU) | DQE | DQE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Maximum (FNU) | DQE | DQE | 558.90 | 527.80 | 311.60 | 1046.30 | 1046.30 |
| Minimum (FNU) | DQE | DQE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| StdDev (FNU) | DQE | DQE | 16.64 | 27.32 | 11.11 | 72.92 | 48.11 |

| **Dissolved Oxygen** | July 23 | July 24 | July 25 | July 26 | July 27 | July 28 | Grand Total |
|---|---|---|---|---|---|---|---|
| Average (mg/L) | 7.98 | 9.85 | 9.18 | 9.17 | 9.19 | 8.85 | 8.86 |
| Maximum (mg/L) | 10.40 | 12.43 | 11.21 | 11.98 | 13.17 | 11.75 | 13.17 |
| Minimum (mg/L) | 5.89 | 8.97 | 8.05 | 8.44 | 6.05 | 5.49 | 5.49 |
| StdDev (mg/L) | 1.30 | 1.03 | 0.25 | 0.58 | 1.38 | 1.34 | 1.25 |

* n with reconstructed GPS coordinates

**Appendix VII:** Calibration and Audit Log recording the accuracy of conductivity in millisiemans per centimeter (mS/cm), pH in standard units, Turbidity in Formazin Nephelometric Units (FNU), and Dissolved Oxygen in milligrams per liter (mg/L). Failed audits are highlighted in bold.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hood Canal | 7/18/2008 | cal | 10.00 | 0.24 | 7.01 | 10.08 | 0.06 | 0.00 | 123.00 | 0.09 | 763.9 | 100.60 | 10.05 | | EG080718 | SA |
| Hood Canal | 7/19/2008 | audit | 10.24 | | 6.95 | 10.10 | 0.02 | -0.09 | 128.30 | 4.31 | 763.9 | 98.90 | 9.29 | 1.70 | | SA |
| Hood Canal | 7/19/2008 | cal | 10.00 | 0.17 | 7.02 | 10.08 | 0.05 | 0.00 | 123.00 | 0.50 | 763.9 | 100.50 | 9.36 | | EG080719 | SA |
| Hood Canal | 7/20/2008 | audit | 9.83 | | 7.07 | 10.04 | 0.04 | -0.50 | 125.60 | 2.60 | 761.7 | 99.80 | 8.88 | 0.70 | | SA |
| Hood Canal | 7/20/2008 | cal | 10.00 | 0.06 | 7.02 | 10.09 | 0.05 | 0.00 | 123.00 | 0.40 | 761.7 | 100.30 | 8.94 | | EG080720 | SA |
| Hood Canal | 7/22/2008 | audit | 9.94 | | 7.07 | 10.07 | 0.02 | -0.40 | 125.600 | 2.60 | 761.2 | 101.90 | 8.98 | 1.60 | | SA |
| Squaxin Island | 7/15/2008 | cal | 10.00 | 0.60 | 7.02 | 10.05 | 0.05 | 0.00 | 123.000 | 0.50 | 760.1 | 100.00 | 9.71 | | SQ080715 | SA |
| Squaxin Island | 7/16/2008 | audit | 9.40 | | 7.07 | 10.05 | 0.00 | 0.50 | 104.300 | **18.70** | 758.3 | 97.90 | 10.03 | 2.10 | | SA |
| Squaxin Island | 7/16/2008 | cal | 10.03 | 0.48 | 7.03 | 10.08 | 0.01 | 0.00 | 123.000 | 2.20 | 758.3 | 99.70 | 10.21 | | SQ080716 | SA |
| Squaxin Island | 7/17/2008 | audit | 10.51 | | 7.02 | 10.03 | 0.05 | -2.20 | 125.200 | 2.20 | 763.9 | 98.30 | 9.84 | 1.40 | | SA |
| Squaxin Island | 7/17/2008 | cal | 10.00 | 0.03 | 7.00 | 10.00 | 0.04 | 0.00 | 123.000 | 0.30 | 763.9 | 100.60 | 10.06 | | SQ080717 | SA |
| Squaxin Island | 7/18/2008 | audit | 10.03 | | 7.04 | 10.03 | 0.03 | 0.30 | 123.200 | 0.20 | 749.2 | 100.10 | 9.89 | 0.50 | | SA |
| Squaxin Island | 7/18/2008 | cal | 10.01 | 0.33 | 7.03 | 10.07 | 0.01 | 0.00 | 123.000 | 0.20 | 749.2 | 100.00 | 10.06 | | SQ080718, SQ080720 | SA |
| Squaxin Island | 7/21/2008 | audit | 10.34 | | 7.04 | 10.09 | 0.02 | 0.20 | 124.300 | 1.30 | 753.4 | 99.30 | 9.85 | 0.70 | | SA |
| Squaxin Island | 7/21/2008 | cal | 10.00 | 0.02 | 7.04 | 10.11 | 0.04 | 0.00 | 123.000 | 0.70 | 753.4 | 100.00 | 10.06 | | SQ080721 | SA |
| Squaxin Island | 7/22/2008 | audit | 10.02 | | 7.08 | 10.09 | 0.02 | -0.70 | 127.600 | 4.60 | 761.9 | 100.00 | 10.15 | 0.00 | | SA |
| Squaxin Island | 7/22/2008 | cal | 10.00 | 0.01 | 7.04 | 10.11 | 0.05 | 0.00 | 123.000 | 0.20 | 761.9 | 100.20 | 10.15 | | SQ080722 | SA |
| Squaxin Island | 7/29/2008 | audit | 10.01 | | 6.99 | 10.07 | 0.04 | 0.20 | 122.300 | 0.70 | 756.8 | 98.40 | 9.37 | 1.80 | | SA |

**Appendix VII (Continued):** Calibration and Audit Log recording the accuracy of conductivity in millisiemans per centimeter (mS/cm), pH in standard units, Turbidity in Formazin Nephelometric Units (FNU), and Dissolved Oxygen in milligrams per liter (mg/L).
Failed audits are highlighted in bold.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Swinomish | 7/22/2008 | cal | 10.00 | 0.09 | 7.02 | 10.05 | 0.06 | 0.00 | 123.200 | 1.00 | 761.2 | 100.70 | 8.83 | | SW080722 | SA |
| Swinomish | 7/23/2008 | audit | 10.09 | | 6.96 | 10.07 | 0.02 | 1.00 | 123.400 | 0.20 | 765.3 | 103.50 | 9.45 | 2.80 | | SA |
| Swinomish | 7/23/2008 | cal | 9.99 | 0.03 | 7.02 | 10.05 | 0.01 | 0.00 | 123.000 | 0.10 | 765.3 | 100.70 | 9.20 | | SW080723-SW080724 | SA |
| Swinomish | 7/26/2008 | audit | 10.02 | | 7.03 | 10.00 | 0.05 | -0.10 | 122.900 | 0.10 | 761.4 | 99.80 | 8.67 | 0.90 | | SA |
| Swinomish | 7/26/2008 | cal | 9.98 | 0.02 | 7.00 | 10.00 | 0.07 | 0.00 | 123.000 | 0.30 | 761.4 | 100.10 | 8.69 | | SW080726-SW080728 | SA |
| Swinomish | 7/29/2008 | audit | 10.00 | | 7.07 | 10.09 | 0.09 | -0.30 | 121.300 | 1.70 | 756.8 | 98.60 | 9.58 | 1.50 | | SA |
| Homalco | 7/23/2008 | cal | 10.00 | 0.04 | 7.02 | 10.04 | 0.08 | 0.00 | 123.000 | 2.80 | 762.2 | 98.40 | 8.50 | | HO080723-HO080724 | SA |
| Homalco | 7/25/2008 | audit | 10.04 | | 7.10 | 9.96 | 0.08 | -2.80 | 140.400 | **17.40** | 761.1 | 99.90 | 8.66 | 1.50 | | SA |
| Homalco | 7/25/2008 | cal | 10.00 | 0.08 | 7.01 | 10.04 | 0.01 | 0.00 | 123.000 | 1.00 | 761.1 | 100.10 | 8.68 | | HO080725-HO080728 | SA |
| Homalco | 7/29/2008 | audit | 10.08 | | 7.02 | 10.07 | 0.03 | -1.00 | 119.900 | 3.10 | 757.2 | 100.30 | 9.96 | 0.20 | | SA |
| Stolo | 7/24/2008 | cal | 9.99 | 0.04 | 7.01 | 4.00 | 0.01 | 0.00 | 123.000 | 0.60 | 766.2 | 100.80 | 9.01 | | ST080724 | SA |
| Stolo | 7/25/2008 | audit | 10.03 | | 7.00 | 3.99 | 0.01 | -0.60 | 124.200 | 1.20 | 762.5 | 100.30 | 8.53 | 0.50 | | SA |
| Stolo | 7/25/2008 | cal | 10.00 | 0.05 | 7.00 | 4.00 | 0.01 | 0.00 | 123.000 | 0.00 | 762.5 | 100.40 | 8.55 | | ST080725 | SA |
| Stolo | 7/26/2008 | audit | 9.95 | | 7.01 | 3.98 | 0.02 | 0.00 | 122.400 | 0.60 | 761.9 | 102.20 | 8.45 | 1.80 | | SA |
| Stolo | 7/26/2008 | cal | 10.00 | 0.20 | 7.00 | 4.00 | 0.03 | 0.00 | 123.000 | 0.50 | 761.9 | 100.30 | 8.26 | | ST080726 | SA |
| Stolo | 7/27/2008 | audit | 9.80 | | 7.03 | 4.00 | 0.00 | 0.50 | 122.000 | 1.00 | 760.3 | 98.70 | 8.66 | 1.60 | | SA |
| Stolo | 7/27/2008 | cal | 10.00 | 0.03 | 7.02 | 10.05 | 0.02 | 0.00 | 123.000 | 0.00 | 760.3 | 100.00 | 8.95 | | ST080727 | SA |
| Stolo | 7/29/2008 | audit | 9.97 | | 7.00 | 10.02 | 0.03 | 0.00 | 117.700 | 5.30 | 759.0 | 99.90 | 9.03 | 0.10 | | SA |