Exploratory Pacific Herring Spawning Habitat Surveys for San Juan County, Washington 2004

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SALMON RECOVERY FUNDING BOARD

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BACKGROUND

Surf smelt *(Hypomesus pretiosus),* Pacific sand lance (*Ammodytes hexapterus*), and Pacific herring (*Clupea harengus pallasi*) spawn throughout the San Juan Archipelago where extensive eelgrass beds and gravel beaches provide habitat for forage fish and salmon alike. Using accepted protocols, the FRIENDS of the San Juans Exploratory Herring Spawning Habitat Assessment Project identified subtidal vegetation supporting herring spawning and provided information on submerged vegetation condition at both potential and known Pacific herring spawning sites for San Juan County. This work builds on the surf smelt and Pacific sand lance spawning and eelgrass assessment work already completed for San Juan County and offers additional information on declining eelgrass populations. Data presented in this report includes all Washington Department of Fish and Wildlife (WDFW) and FRIENDS of the San Juans (FSJ) herring spawn surveys in San Juan County waters for the 2004 field season, at both exploratory and previously documented sites.

Pacific herring depend on healthy nearshore marine habitats for spawning and rearing. Protection of nearshore habitats utilized by forage fish in these key life history stages as well as by juvenile salmon will be needed if salmon recovery is to be successful. Under Washington Administrative Code "Hydraulic Code Rules" (WAC 220-110), WDFW presently has authority to protect all known, documented Pacific herring, Pacific sand lance, and surf smelt spawning sites from shoreline development impacts. These rules are applied by WDFW marine habitat managers during considerations for shoreline development proposals. Thus it is critical for overall protection of these habitats that site inventories of forage fish spawning and eelgrass extent be complete.

Documenting specific locations of spawn and describing vegetation communities will contribute to the knowledge and understanding of herring spawn habitat in the San Juan Islands. As with the recently completed assessments of surf smelt and Pacific sand lance spawning beaches and eelgrass mapping, results of the Pacific herring spawn survey will be included in the San Juan County Nearshore Habitat Database. Results will be provided to San Juan County and WDFW managers to allow rapid use of the information during the review of permits for shoreline development and long-range planning processes including critical habitat areas updates in 2005.

Adult herring stocks in Puget Sound spawn at specific sites or 'grounds'. The specificity of herring spawning areas and their location in nearshore marine

environments make Pacific herring spawning grounds vulnerable to impacts from shoreline and upland development (WDFW 2000). Two stocks of spawning Pacific herring are recognized by WDFW in San Juan County. One stock spawns in the Westcott Bay Region, while the other spawns at scattered locations on Lopez, Orcas, and Shaw Islands (Lemberg et al. 1996, Penttila 1999). Spawning in the San Juans occurs from late January through early April (Penttila 1999, Stick 2004). Herring spawn from the upper intertidal region to a depth of 40 feet, but most spawning is between 0 and –10 ft MLLW. In San Juan County, spawning is generally on eelgrass (*Zostera marina*) or a fibrous red alga known as *Gracilariopsis* (Penttila 1999).

Washington Department of Fish and Wildlife has been conducting spawn assessments of know Pacific herring spawning grounds for most of Puget Sound since 1973 (Penttila 1999). Exploratory surveys of potential or historic spawning habitat have been extremely limited, particularly in remote survey regions such as the San Juan Islands. Annual herring spawning surveys on known grounds in San Juan County have been sporadic over the last twenty years, with insufficient data to evaluate population trends (Penttila 1999). Resource issues related to declining budgets and the remote nature of San Juan County herring sites have reduced WDFW sampling of even the known sites in recent years. The documented Eastsound herring spawning grounds were last sampled by WDFW in 2000 (Stick 2004).

Nearshore marine assessment work conducted over the past three years in San Juan County included surf smelt and Pacific sand lance spawning habitat assessments and comprehensive mapping of eelgrass communities. During this extensive nearshore assessment and community outreach process, reports of possible herring spawn activity at unmonitored sites were collected and the presence of additional suitable potential herring spawning substrate was documented.

The Exploratory Herring Spawn Habitat Assessment Project identified, mapped and surveyed priority potential Pacific herring spawn habitat, collected information on subtidal vegetation diversity and condition and supported WDFW sampling efforts at known Pacific herring spawn locations. This work builds on forage fish assessments completed for San Juan County and offers additional information on declining eelgrass populations to further focus salmon recovery research, protection and restoration efforts.

PROJECT PARTNERS

The **Exploratory Pacific Herring Spawn Habitat Assessment Project** was initiated in 2003. Project partners and roles include:

FRIENDS of the San Juans (FSJ) manages the project. FSJ provides project design, coordination field staff, data analysis, mapping and reporting. FSJ compiles information on potential herring spawning sites as well as WDFW data from known spawning grounds into the Nearshore Habitat Database. FSJ manages volunteers and nearshore outreach and education. FSJ provides data in report and spatial format to local, state, federal, tribal and non-governmental coastal planners and scientists.

The **San Juan County Marine Resources Committee** (MRC) has been a partner in the San Juan County Forage Fish Project since 2000. Dr. Lawrence Moulton, acting as the MRC forage fish coordinator, assisted with project design and technical review.

Washington Department of Fish and Wildlife (WDFW), through Dan Penttila and Kurt Stick, provided protocol, field and lab training, and technical expertise. A 30-year member of the Washington Department of Fish and Wildlife (WDFW), Penttila has led the research and inventory of forage fish spawning habitats throughout Puget Sound and the Washington Coast. Kurt Stick coordinates the region's Pacific herring spawning research, stock assessment and management programs. Information from WDFW was used to identify and prioritize potential spawning habitats. WDFW field researchers conducted annual herring spawn assessments at four of the five know herring spawning areas in San Juan County in 2004. Washington Department of Fish and Wildlife applies San Juan County Nearshore Project data in its Hydraulic Project Approval Process. FSJ employed standard WDFW Pacific herring spawn sampling protocol in all surveys.

University of Washington Friday Harbor Laboratories provides boat moorage, potential habitat information and lab support for sample analysis.

San Juan County applies forage fish project data to the review and action of shoreline project applications. Direction from the Board of County Commissioners to all County Department Heads in a Memorandum of Understanding (MOU) addresses the role of forage fish data. The MOU states

that through the Marine Resources Committee, the county is participating in the inventory and mapping of nearshore habitat for spawning forage fish. The memorandum instructs all county department directors to use the information as 'best available science'.

SURVEY

Protocol Training and Database Development

Washington Department of Fish and Wildlife Herring Spawn Deposition Surveys employ the grappling of submerged marine vegetation and other substrates at depths from +2 to -50 tidal elevation, generally at 200 to 400 yard intervals along the shorelines of known spawning grounds (WDFW 1973). The geographic location, date and time of each sample is recorded, as is grappled vegetation type (to genus) and herring spawn intensity (eggs/inch of substrate). Positive spawn samples are collected and preserved. Spawn deposition intensities are used by WDFW to estimate Pacific herring biomass for that spawning ground. The FSJ 2004 Exploratory Pacific Herring Spawning Habitat Assessment Surveys followed standard WDFW spawn deposition survey protocol; biomass estimates for San Juan County herring grounds will be determined by WDFW.

In the winter and spring of 2003 FSJ Environmental Program Manager was trained in WDFW Herring Spawn Survey Protocol by serving as the second staff on WDFW San Juan County field surveys. Training included review of the WDFW Pacific Herring Stock Assessment protocol manual and multiple days of field survey experience. FSJ field staff also spent two field days with WDFW on Pacific herring spawn surveys in San Juan County at the start of the 2004 field season.

The WDFW herring survey protocol field record sheet and San Juan County's existing, spatially explicit Geographic Information Systems and Access nearshore habitat database were used as the basis for compiling the herring data. In addition to the standard WDFW herring spawn protocol records, data fields for eelgrass plant condition, other spawn identified in the course of surveys and easily visible invertebrates were added to provide a more comprehensive picture of the condition of Pacific herring spawning habitat in San Juan County waters. The nearshore habitat database houses the 'best available science' on nearshore marine conditions in San Juan County, including surf smelt and Pacific sand lance spawning assessment results, eelgrass mapping results and additional factors such as county infrastructure and harvested marine resources. All information from the nearshore habitat database is public and is shared with local, state, federal, tribal and nonprofit land managers and scientists.

Exploratory Herring Spawn Surveys

Washington Department of Fish and Wildlife has been conducting annual spawn assessments for most known herring spawning locations since 1973 (Penttila 1999). Despite credible reports of spawn activity and the existence of potential spawning habitat in numerous embayments with eelgrass or *Gracilariopsis* beds, exploratory surveys of potential Pacific herring spawning habitat in San Juan County have been extremely limited.

Potential spawning sites for inclusion in the exploratory Pacific herring spawning surveys were identified and prioritized using information from Washington Department of Fish and Wildlife, Friday Harbor Marine Laboratories, historic reports, San Juan County Forage Fish and Eelgrass Project Assessments, and through a series of interviews with key community members. Interviews on anecdotal or known historic and potential current Pacific herring spawning activity in the San Juan Islands were conducted by FSJ in 2003 with local elders, scientists and commercial fisherman.

Credibly reported potential Pacific herring spawning sites were noted for 21 shallow-water areas near the following islands: Lopez (2); Orcas Island (2); San Juan Island (3); Brown Island (1); Shaw Island (3); Stuart Island (2); Sucia Islands (4); Patos Island (1); and Waldron Island (3). See *Table I: Priority Potential Pacific Herring Spawning Survey Sites in San Juan County*.

Exploratory field surveys of potential Pacific herring spawning habitat in San Juan County were conducted in late winter and spring of 2004 at 21 potential spawning locations. Each site was visited a minimum of two times during the winter/spring 2004 Pacific herring spawning season in San Juan County.

Table I: Priority Potential Herring Spawning Locations in San Juan County.

Island	Region	Sources
Lopez	Fisherman's Bay	WDFW
Lopez	Rock Pt. to Shark Reef	Lopez resident/fisheries biologist
Orcas	Pole Pass	WDFW, Historic reports
Orcas	Central and South Eastsound	WDFW, Historic reports
San Juan	Cattle Point	Fisherman
San Juan	False Bay	Forage Fish Project
San Juan	Kanaka Bay	Fisherman
San Juan/Brown	Shipyard Bay	Friday Harbor Labs
Shaw	Parks Bay	Forage Fish Project
Shaw	Hicks Bay	Forage Fish Project
Shaw	Hoffman Cove	Forage Fish Project
Stuart	Reid Harbor	Fisherman and tribes
Stuart	Prevost Harbor	Fisherman
Sucia	Shallow Bay	WDFW, Historic Records
Sucia	Fox Cove	WDFW
Sucia	Fossil Bay	WDFW
Sucia	Echo Bay	Historic Records
Patos	Northeast End	Fisherman
Waldron	Mail Bay	Historic Records, fisherman, tribes
Waldron	Cowlitz Bay	Fisherman, elders
Waldron	North Bay	Elders, fisherman

Surveys of Known Herring Spawn Sites

Pacific herring spawning activity in San Juan County over the past 30 years has been documented in five areas within San Juan County waters. These include: the Westcott/Roche Harbor Region of San Juan Island; Mud and Hunter Bays on Lopez Island; Blind Bay on Shaw Island; Eastsound on Orcas Island and West Sound, also on Orcas Island (Penttila 1999). See *Figure I: Exploratory and Known Pacific Herring Spawning Survey Sites in San Juan County.*

In addition to surveying priority potential Pacific herring spawning sites, FSJ also conducted surveys at four of the five known herring spawning locations in

the county, supporting the ongoing survey effort conducted annually by Washington Department of Fish and Wildlife. Resource issues related to declining budgets and the remote nature of San Juan County herring sites have reduced WDFW sampling of known sites, with the Eastsound location excluded from WDFW surveys in recent years. The FRIENDS of the San Juans Exploratory Herring Spawn Assessment Project addressed these data gaps and conducted surveys throughout San Juan County in 2004. As all exploratory and known spawning site surveys by WDFW and FSJ are conducted with the same protocol, results are compatible and shared, increasing the geographic and temporal scope of both efforts.

A total of 501 rake samples of grappled submerged vegetation were collected in the 2004 Pacific herring spawn season in San Juan County. FRIENDS of the San Juans 2004 surveys included 204 samples collected from 21 exploratory and four known Pacific herring spawn regions in San Juan County. Seventy-four percent (150 0f 204) of the FSJ surveys were conducted in exploratory, potential spawn habitat areas, with the remaining FSJ samples taken from the known spawning grounds of Blind Bay, West Sound, Eastsound and Westcott/Garrison. 2004 survey totals for WDFW included 297 samples taken from four known Pacific herring spawning grounds and one exploratory site. See *Figure II: 2004 WDFW and FSJ Herring Spawn Survey Sites*. In general, the FSJ samples were more widely distributed than the WDFW samples, in an attempt to cover more potential spawning area over the course of the spawning season. WDFW samples were more densely grouped and focused on the known spawning regions of Blind Bay, Mud-Hunter, West Sound and Westcott/Garrison. WDFW did not survey the known Eastsound spawning grounds, but did include a few exploratory sites in the thick eelgrass *(Zostera marina)* and *Gracilariopsis* beds at Orcas Bay.

Table II: San Juan County Pacific Herring Spawn Habitat Surveys - 2004.

2004 Surveys	WDFW	FSJ	Totals
Known Spawning Ground Samples	294	54	348
Exploratory Sites	3	150	153
Totals	297	204	501

RESULTS

Overall the 2004 sampling season results were characterized by very light Pacific herring spawn in the San Juan Islands. Despite expanded survey efforts spawn was documented at fewer locations and in lighter egg densities than is typical for the region. Positive Pacific herring spawn was documented in four of the five known Pacific herring spawn regions of the county, including West Sound, Orcas Island; Blind Bay, Shaw Island; Eastsound, Orcas Island; and Mud Bay, Lopez Island. See *Figure III: Documented Pacific herring spawn in San Juan County- 2004*. A total of 17 samples (3%) in 2004 were positive for Pacific herring spawn deposition and spawn intensities were defined as very light or trace for all samples.

Table III: Documented Pacific Herring Spawn in San Juan County- 2004.

Known Herring Spawn Region	2004 Results	Spawn Intensity	Spawn Area	Survey Dates (documented spawn in bold)
Westcott/Garrison Bay	No Spawn Documented in 2004	N/A	No spawn activity in previously documented areas	1/29/04, 2/12/04, 2/27/04, 3/8/04, 4/9/04
Roche Harbor	No Spawn Documented in 2004	N/A	No spawn activity in previously documented areas	1/29/04, 2/12/04, 2/27/04, 3/8/04, 4/9/04
Mud Bay	Spawn Documented in 2004	Very light		2/12/04, **2/26/04, 3/9/04, 3/24/04, 4/9/04**
Hunter Bay	No Spawn Documented in 2004	N/A	No spawn activity in previously documented areas	2/12/04, 2/26/04, 3/9/04, 3/24/04, 4/9/04
Blind Bay	Spawn documented in 2004	Very light	Spawn area reduced from previous years	2/12/04, 2/26/04, **3/9/04, 3/24/04, 4/8/04, 4/9/04**
West Sound	Spawn documented in 2004	Very light	Spawn area reduced from previous years	2/12/04, 2/26/04, 3/23/04, **3/24/04**, 4/8/04
Eastsound	Spawn documented in 2004	Very light	No data from 2001-2003; spawn area reduced from pre-2001 years.	**4/2/04**

Positive spawn area within the additional four known spawning grounds was reduced in 2004, a potential indication of low Pacific herring numbers and/or a loss of suitable spawning substrate. Spawn of very light intensity was

documented in West Sound, at just one location at the north end of the sound on one date in March. Very light herring spawn was noted on four survey days in March and April in Blind Bay. Spawn activity in Blind Bay was limited to a few sites in the western portion of the bay. Very light Pacific herring spawn was documented at two survey sites in the northwest corner of Ship's Bay in Eastsound in early April. Very light (n=4) and trace (n=2) herring spawn deposition was noted on four survey dates from February through April in Mud Bay on Lopez Island. No spawn was documented in Hunter Bay in 2004. See *Figure IV: Spawn Areas of Concern- Known Spawning Grounds with No Spawn Activity in 2004.*

No Pacific herring spawn activity was documented in 2004 for the Roche Harbor, Mosquito Pass and Westcott/Garrison Bay stock; suggesting that the eelgrass declines may have resulted in direct impacts to Pacific herring spawn activity in the region. In an attempt to monitor herring response to the dramatic eelgrass declines within the Westcott/ Garrison Bay spawning grounds, the number, season and geographic extent of surveys were expanded. In addition to grapples of submerged vegetation throughout the region in 2004, survey methods to identify herring use of the region were expanded to include plankton tows. Plankton tows were conducted by WDFW in Westcott Bay on February 12, 2004 and February 27, 2004, but yielded no herring larvae. Survey efforts documented continued declines of submerged vegetation within Westcott Bay as well as the availability of spawning substrate (primarily eelgrass and *Gracilariopsis*) in the Mosquito Pass and Roche Harbor areas.

SPAWNING HABITAT

Pacific herring spawn deposition within San Juan County generally occurs on the native eelgrass, *(Zostera marina),* and the mud-bottom dwelling red alga, *Gracilariopsis* (Penttila 1999). Herring spawn from the upper intertidal region to a depth of 40 feet, with most spawn occurring between 0 and –10 Ft. MLLW. While comprehensive information is now available for eelgrass distribution in San Juan County, there is limited data on plant condition or other species of submerged vegetation. The Exploratory Herring Spawn Habitat Assessment Project begins to address these finer scale data gaps in San Juan County by focusing field efforts on submerged vegetation in potential Pacific herring spawn locations.

Information was collected on the presence or absence of over 25 species of aquatic vegetation, per standard WDFW herring spawn assessment protocol (WDFW 1973). For eelgrass (*Zostera marina),* information on bed thickness and plant condition was also recorded. Survey sites with both eelgrass and G*racilariopsis* present were identified and mapped to show the distribution of suitable herring spawning substrate within the 2004 exploratory and known spawning ground survey regions. See *Figure V: High Value Herring Spawn Habitat- Eelgrass and Gracilariopsis cover within 2004 survey regions.*

Significant declines in submerged vegetation communities have been documented at multiple sites in the San Juans over the past few years of Pacific herring spawn field surveys (Penttila 2004). These declines were confirmed by comprehensive eelgrass mapping conducted in the summer of 2003 (FSJ et al. 2004). Rapid and dramatic loss of eelgrass in Westcott and Garrison Bays on San Juan Island and lesser declines in Blind Bay on Shaw Island have increased concerns and focused attention on the potential impacts upland activities may be having on water quality and vegetation conditions in the nearshore. With these concerns in mind, information on eelgrass plant condition was added to the Pacific herring spawn survey field records (Wyllie-Echeverria 2004). In addition, WDFW field surveyors make general comments in the notes portion of their field records; a summary of potential problem areas is provided below.

The presence of soft or 'pithy' roots of eelgrass plants was noted at multiple sample sites in three areas: Blind Bay, Westcott Bay and the easternmost portion of Prevost Harbor, in the small embayment southeast of Satellite Island and at the end of the Stuart airstrip. Degraded individual plant condition was noted at the start of the Westcott Bay eelgrass decline and has also been noted in Blind Bay, another area of concern for its reduction in eelgrass (Wyllie-Echeverria 2004). See *Figure VI. Habitat Areas of Concern- Poor Eelgrass Plant Condition.*

Research biologists from WDFW return to the same Pacific herring spawn survey regions each year. In San Juan County, the predominant herring spawning substrate is our native eelgrass (*Zostera marina).* Initial information on eelgrass declines in the Westcott/Garrison Bay region of San Juan County resulted from the comment field of herring survey forms, as WDFW surveyors familiar with eelgrass beds first noted declines in 2001 (Penttila 2004). This loss of more than 35 acres in eelgrass area was confirmed through comparisons with herring survey data from past years and results of the 2004

comprehensive eelgrass mapping project (Wyllie-Echeverria et al. 2003, FSJ et al. 2004).

While the conditions that caused the dramatic declines in Westcott Bay are presently unknown, there is concern that similar declines could be occurring throughout San Juan County and the Puget Sound/Georgia Basin Ecosystem. An interdisciplinary team has been convened to: 1. Improve local and regional awareness of the problem, 2. Determine a scientifically based program to identify causes, and 3. Initiate protection and restoration efforts, if warranted (Wyllie-Echeverria et al. 2003). To date the work group has informed agencies and citizens of what is known about the loss of eelgrass, initiated water quality and upland character assessment, and continues to build support for expanded research and analysis.

The likelihood of additional Pacific herring spawning habitat areas experiencing eelgrass decline are apparent through a review of 2004 herring spawn survey field notes. Three of the five documented Pacific herring spawning regions in San Juan County had eelgrass declines noted by WDFW researchers in 2004, including Blind Bay, Shaw Island; West Sound, Orcas Island; and continued loss at Westcott and Garrison Bays, San Juan Island. These sites should receive further investigation (analysis of historical data, photos, and field surveys) and possible protection or restoration efforts. While additional declines could be occurring in the county, the only beds surveyed annually are those that occur in known Pacific herring spawning regions. See *Figure VII: Habitat Areas of Concern- Potential Eelgrass Decline Noted by WDFW Researchers* and *Table IV: Observed Potential Eelgrass Decline in Known Pacific Herring Spawn Regions*.

Table IV: Potential Eelgrass Decline in Known Pacific Herring Spawn Regions

Region	Date	Source	Description
Westcott/ Garrison	1/29/04	Penttila, Harris (WDFW)	It is apparent that the native eelgrass continues to decline, from its scanty distribution found last season. Every station from 20-51, just about the entire perimeter of the bays showed "no vegetation". Normal looking vegetation found in Mosquito Pass and SE Roche Harbor region.
Westcott/ Garrison	2/12/04	Penttila (WDFW) Hagerman (FSJ)	Eelgrass was present at one station and sparse *Gracilariopsis* was noted off Bell Point, the last consistent herring spawning site in the bay.
Westcott/ Garrison	2/27/04	Penttila (WDFW) Whitman (FSJ)	Beds of *Gracilariopsis* are available in outer Westcott bay for local herring to spawn upon in the near absence of eelgrass around the perimeter of Westcott and Garrison Bays.
Blind Bay	2/12/04	Stick, McAllister (WDFW)	The lack of eelgrass was observed at the southernmost end of Blind Bay, in an area that previously had eelgrass.
Blind Bay	2/26/04	Penttila (WDFW) Whitman (FSJ)	Eelgrass largely absent south of a line between station #3 and #14. The 'usual' spawning site around station #8 had *Ulva* as the primary spawning substrate. No herring spawn was found.
Blind Bay	3/9/04	Stick, Whitney (WDFW)	Lack of eelgrass at south end was again noted.
West Sound	2/26/04	Penttila (WDFW) Whitman (FSJ)	Sampling around West Sound Marina we did not find much available vegetation substrate. I could not locate what I had recalled as a dense eelgrass bed east of Picnic Island.

CONCLUSION

With the listing of many Puget Sound salmon stocks as threatened or endangered, the issue of maintaining healthy forage fish stocks and nearshore marine environments for salmon has been identified as a high priority. Pacific herring, one of three significant forage fish species in San Juan County waters, utilize submerged vegetation in nearshore marine environments to spawn. In San Juan County, eelgrass (*Zostera marina*) is the primary substrate utilized by Pacific herring for egg deposition (Penttila 1999). Eelgrass also provides critical habitat for a number of significant marine and estuarine animals, including rearing, feeding and migrating habitat for juvenile salmon.

Expanded monitoring for 2004 Pacific herring spawn activity in San Juan County was monitored by WDFW and FSJ researchers. Five known and twenty-one credibly reported potential spawning sites were sampled using standard WDFW herring spawn deposition survey protocol. Very light or trace Pacific herring spawn was noted at four out of the five known grounds. No spawn was documented in 2004 for the Westcott/Garrison Bay stock of Pacific herring. No herring spawn was documented in exploratory potential spawn habitat areas.

Dramatic eelgrass declines first noted in 2001 (Penttila 2004, Wyllie-Echeverria et al. 2003) in the Westcott/Garrison Bay region of San Juan Island were again noted in 2004 surveys and a very limited amount of eelgrass remains inside the bays. Potentially significant eelgrass declines in other known Pacific herring spawning grounds in San Juan County (West Sound-Orcas Island and Blind Bay-Shaw Island) were also noted.

While many regions of high quality submerged habitat were identified and mapped during the 2004 surveys of known and exploratory Pacific herring spawn habitat in San Juan County, declines in both spawn habitat and spawn deposition at a majority of the currently known herring spawning sites is cause for concern for this priority species and associated critical habitat. Expanded Pacific herring spawn deposition and habitat assessment efforts should be continued. Data from past WDFW Pacific herring spawn surveys can be analyzed to determine changes in geographic extent of both herring spawn deposition and submerged vegetation species. Spawning populations of Pacific herring fluctuate over time; exploratory surveys for Pacific herring spawn at potential habitat areas should be continued in an effort to collect samples during a higher herring population year. Additional resources should

be focused on determining the cause of declines in nearshore vegetative communities and to identifying any protection and restoration measures that may be required to ensure healthy nearshore habitat and forage fish populations for salmon recovery.

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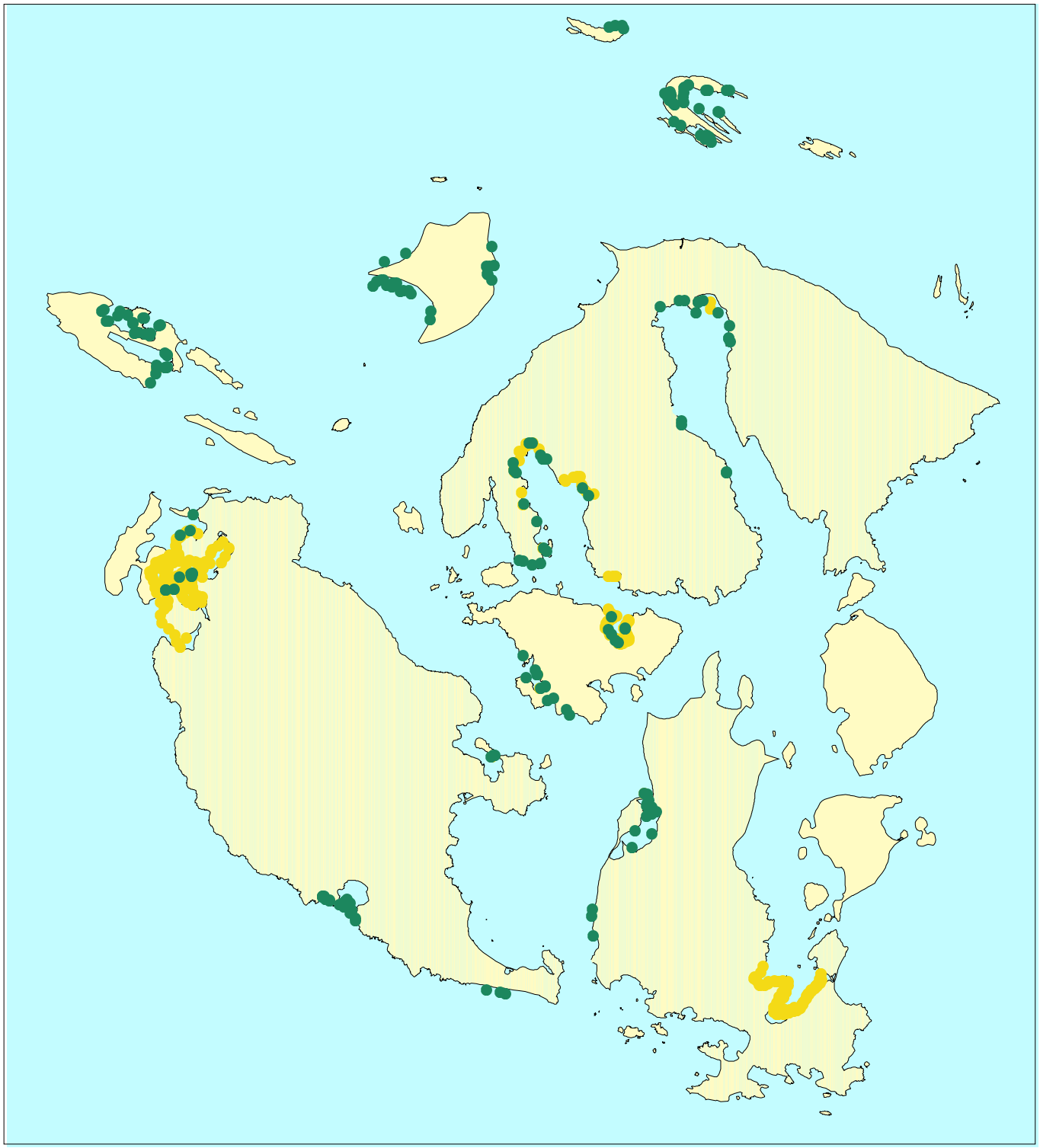
Figure 1
Exploratory and Known Pacific Herring Spawning
Survey Sites in San Juan County 2004

- Exploratory Sites
- Known Sites

Figure 2
2004 WDFW and FSJ Herring Spawn Survey Sites

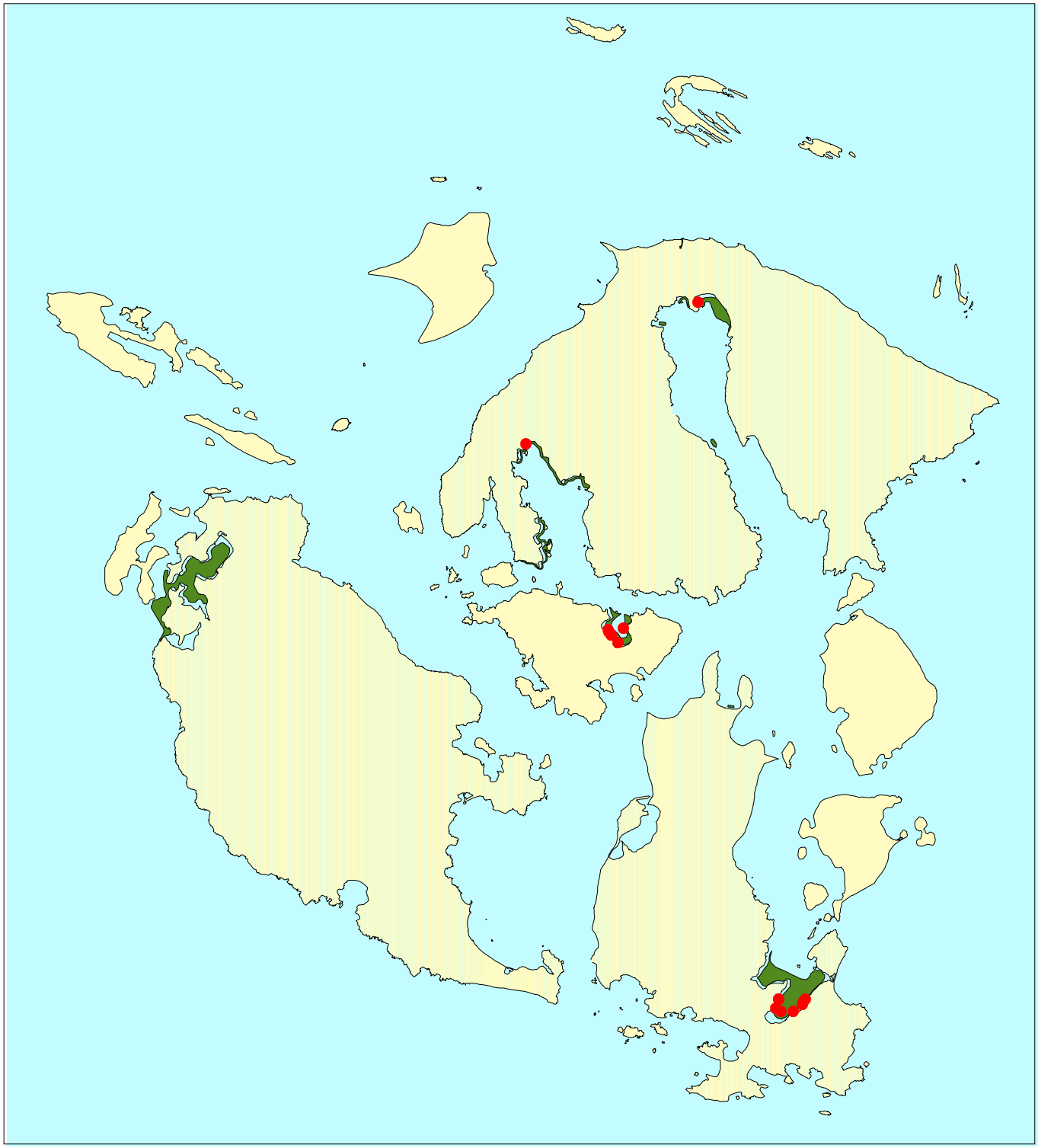


- WDFW Herring Spawn Survey Sites
- FSJ Herring Spawn Survey Sites

Figure 3
Documented Pacific Herring Spawning Sites in San Juan County 2004

● Positive Herring Spawning Sites in 2004

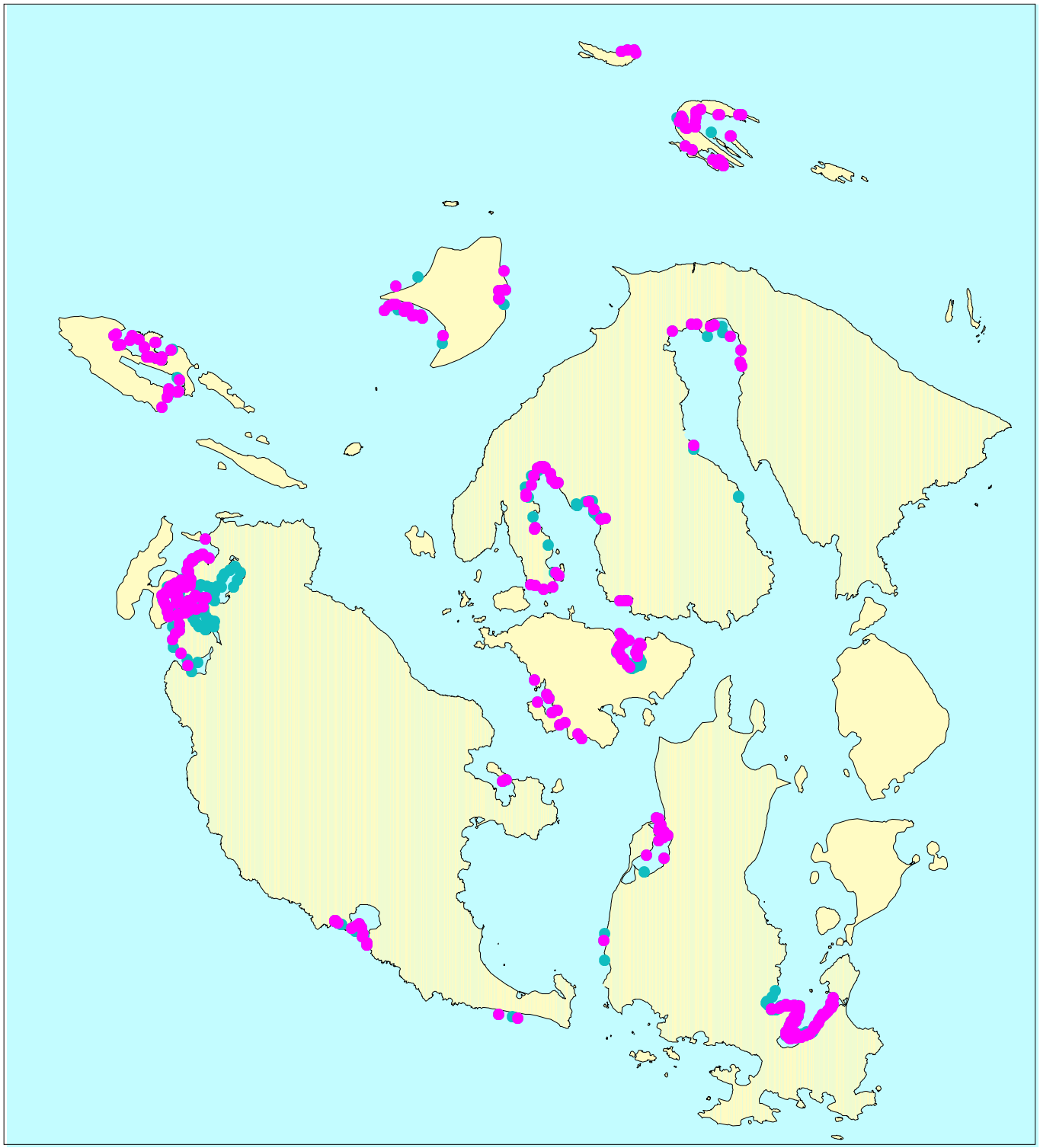
Figure 4
Spawn Areas of Concern - Known Spawning grounds with No Spawn Activity in 2004



Positive Herring Spawning Sites in 2004

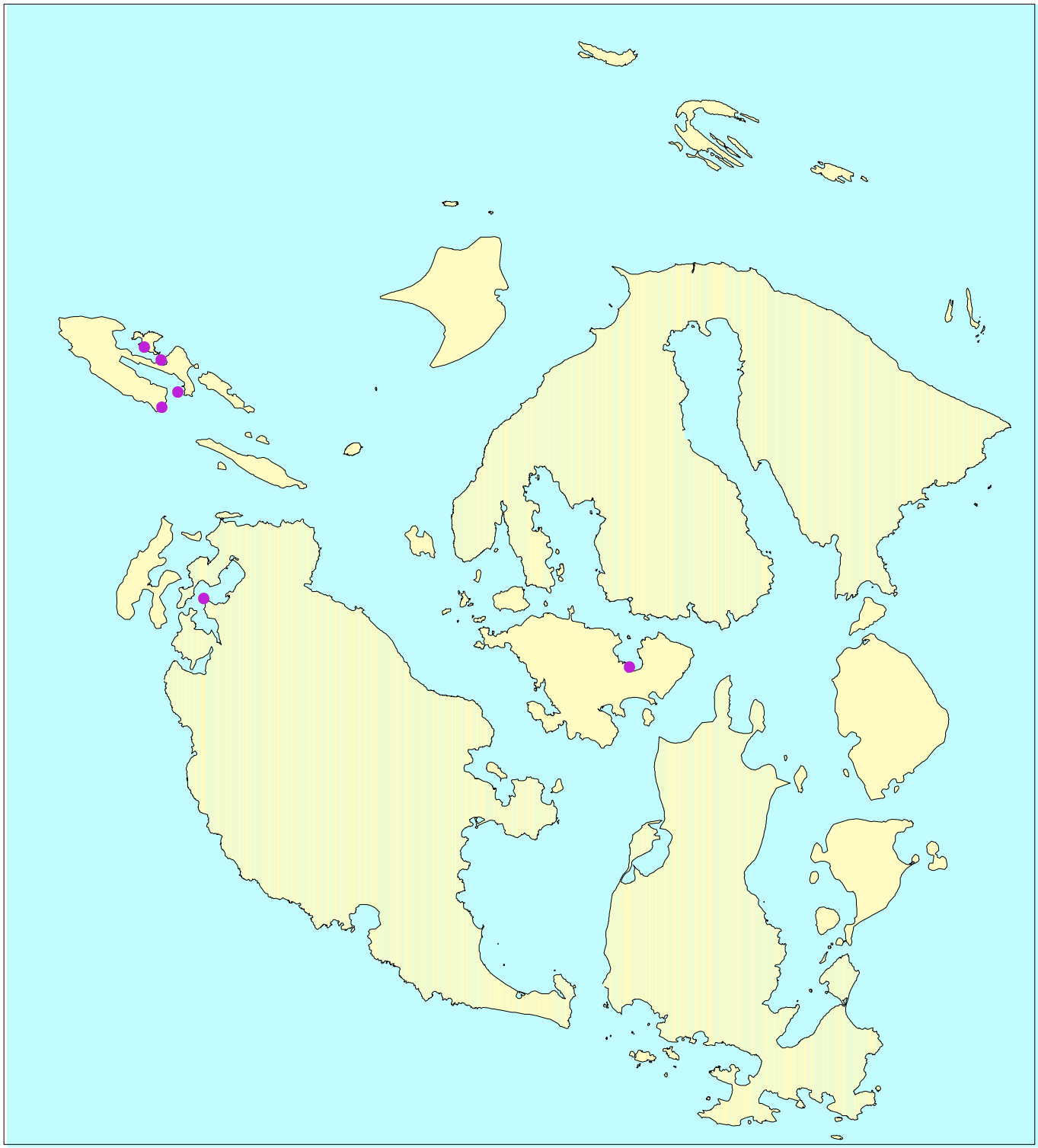
Known Spawning Grounds with No Spawn Activity in 2004

Figure 5
High Value Herring Spawn Habitat - Eelgrass and Gracillariopsis Vegetative Cover



- Herring Sample Sites with Eelgrass and Gracillariopsis
- Herring Sample Sites without Eelgrass and Gracillariopsis

Figure 6
Habitat Areas of Concern - Poor Plant Condition Samples

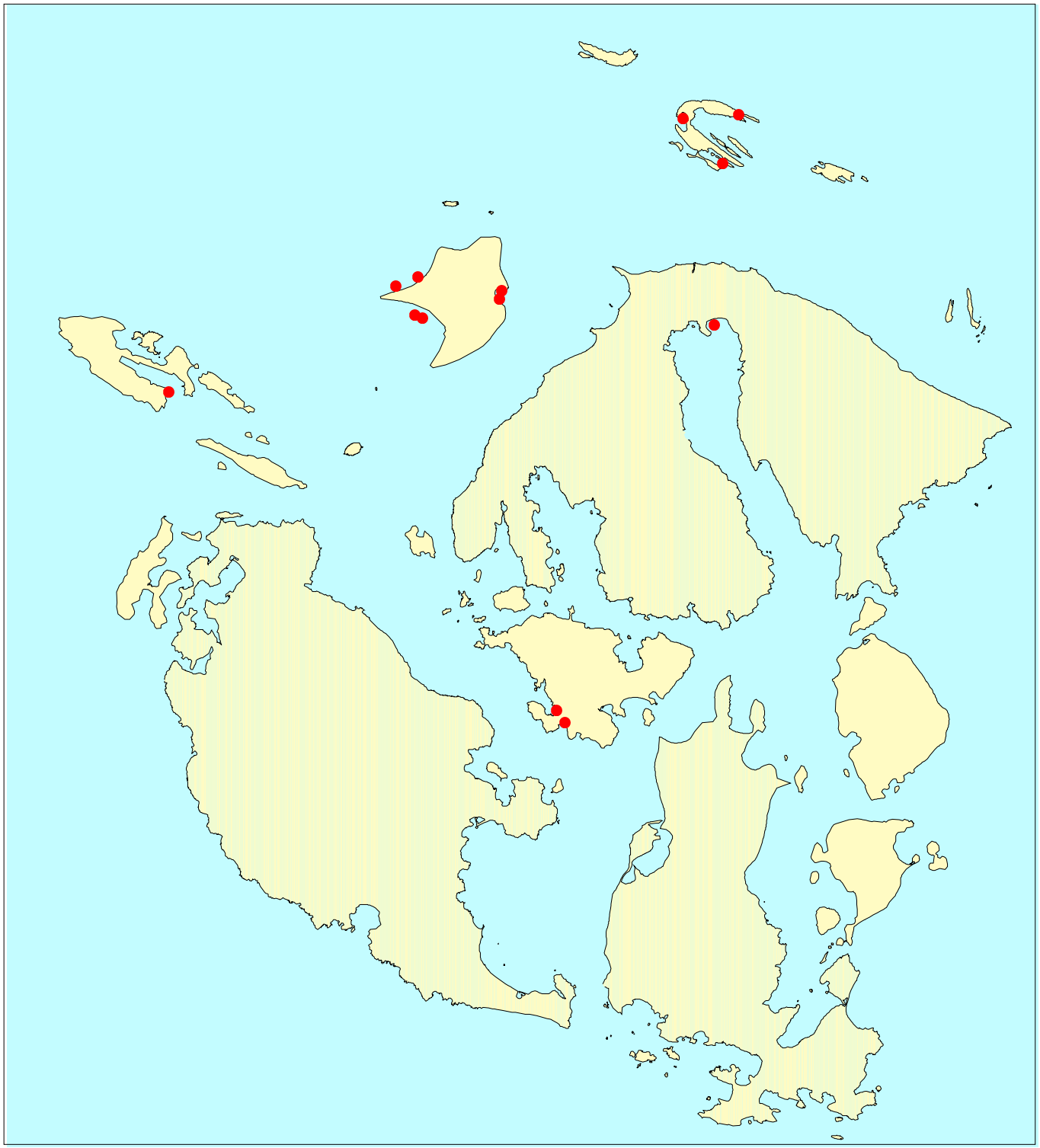


● Potential Unhealthy Eelgrass - Poor Plant Condition

Figure 7
Habitat Areas of Concern - Eelgrass Decline Noted by WDFW Field Researchers

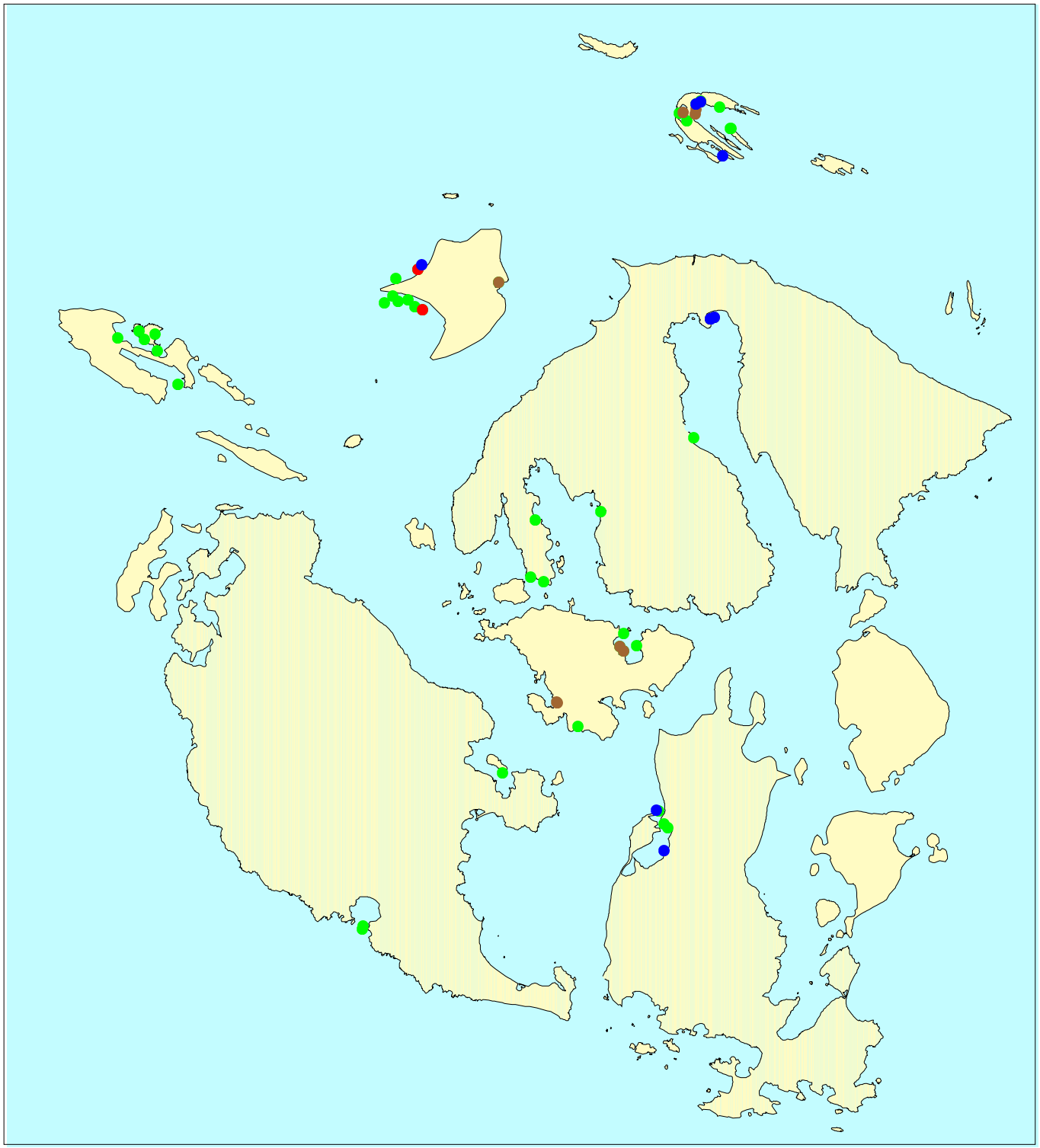
Eelgrass Decline Noted by WDFW Field Researchers

Appendix A
Non-Herring Fish Spawn Activity



● Non-Herring Fish Spawn Activity (Tubesnout or Sculpin)

Appendix B
Invertebrates Observed in FSJ Herring Spawn Survey



- Phy. Taylori
- Isopods
- Melibe
- Lacuna Eggs