Preliminary aerial reconnaissance surveys of eelgrass beds on Togiak National Wildlife Refuge, Alaska, 2004

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Abstract

An aerial reconnaissance survey of Togiak National Wildlife Refuge (Togiak Refuge) coastlines was conducted on 6 August, 2004, in an effort to identify locations of eelgrass (*Zostera sp.)* beds to assist in plans for future monitoring efforts. Twenty-three eelgrass and eelgrass-kelp beds were identified on Togiak Refuge coastlines. Eelgrass beds are ecologically important as primary producers in the food web, and as a source of cover from predators for fish and invertebrates. Due to apparent worldwide eelgrass declines and its importance in the Bristol Bay ecosystem, Togiak Refuge has identified the need for the collection of baseline eelgrass distribution data and the implementation of a long-term monitoring plan of refuge coastlines.

Introduction

Seagrass meadows are one of the most common and productive marine habitats, and play an important role in the overall health of coastal ecosystems (Ferguson *et al.* 1993, Klemas *et al.* 1993, Short and Wyllie-Echeverria 1996, Thayer *et al.* 1975). Seagrass beds reduce water's wave energy, stabilize sediments, assimilate nutrients, support a high diversity of plants and animals, and are primary producers in the coastal marine energy cycle (Ferguson *et al.* 1969, McRoy and McMillan 1977, Short and Wyllie-Echeverria 1996). However, seagrasses are declining worldwide (Dennison *et al.* 1993, Klemas *et al.* 1993, Short and Burdick 1996). Anthropogenic causes such as dredging, certain fishing practices, pollution, sediment runoff, and turbidity are partially responsible for the decline (Thayer *et al.* 1975, Short and Wyllie-Echeverria 1996). Additionally, rising ocean levels and increasing temperatures from climate change also contribute to seagrass declines (Ferguson *et al.* 1993, Klemas *et al.* 1993, Thayer *et al.* 1975, Short and Wyllie-Echeverria 1996).

Eelgrass (*Zostera spp.*) occurs throughout the world. *Zostera* occurs on both the Atlantic and Pacific coasts of North America and extends from Baja, Mexico to the Bering and Chukchi seas (McRoy 1970). Eelgrass represents the dominant seagrass community in Alaska, and is also the most studied seagrass in the state (McRoy 1968). *Zostera* grows in soft sediments of protected bays, inlets, and lagoons in Alaska, (McRoy 1968) and plays an important role in their ecosystems. Eelgrass beds in Sawmill Bay, Izembek Lagoon, Kinzarof Lagoon, and Safety Lagoon are the most heavily researched, though eelgrass beds have been documented at many locations along the coastline of Alaska (McRoy 1970). In the Bristol Bay and Kuskokwim Bay region, Nanvak and Chagvan Bays have the only documented eelgrass beds (McRoy 1968). However, nearshore underwater surveys using acoustic and visual techniques indicate eelgrass is present in Metervik and Ungalikthluk Bays, but no density estimate was calculated (Bornhold and Harper 2003). Little information is available on eelgrass distribution in Bristol Bay outside of Nanvak and Chagvan Bays.

Eelgrass makes many important contributions to nearshore ecosystems (Ferguson *et al.* 1993, Klemas *et al.* 1993, Thayer *et al.* 1975, Ward *et al.* 1997, Ward *et al.* 2003). Submerged aquatic vascular plants, such as eelgrass, provide the basic structure for the ecosystem's food web through primary production and creation of physical habitat (McRoy and McMillan 1977, Short and Wyllie-Echeverria 1996). Seagrass beds have a higher faunal density compared to nearby non-vegetated areas (Thayer *et al.* 1975). Epiphytes commonly utilize nutrients provided by eelgrass and are an additional primary producer in seagrass ecosystems (McRoy and McMillan 1977, Thayer *et al.* 1975). Wood *et al.* (1969) found diatomic epiphytes at high densities of up to13.33 mg per gm of eelgrass leaf, and many animals that live in seagrass systems are epiphytic grazers.

Waterfowl, fish, and invertebrates directly and indirectly depend on eelgrass beds along the Togiak Refuge coastline. Chagvan and Nanvak Bays are important migration stopover sites for Black Brant (*Branta bernicula nigricans*) and Steller's Eiders (*Polysticta stelleri*) (Togiak National Wildlife Refuge, 2004). Black Brant consume eelgrass to replenish energy reserves during spring and fall migrations (Moore *et al.* 2004, Wilson and Atkinson 1995). Steller's Eiders feed on invertebrates in eelgrass beds during spring and fall migrations. Eelgrass detritus controls secondary production by providing a food source to invertebrate filter feeders and particulate consumers (Wood *et al.* 1969, Short and Wyllie-Echeverria 1996), which in turn are consumed by fish.

In addition to its role in primary and secondary production, eelgrass provides structural protection from predators and also acts as a spawning medium for fish such as herring. Eelgrass is directly linked to the economy through the Bristol Bay region herring fishery. The Togiak herring fishery is the largest in Alaska, with an average herring stock biomass of 137,063 tons from 1993-2002 (Weiland *et al.* 2003). The value of the Togiak herring fishery in 2003 was approximately $3.2 million (Weiland *et al.* 2003).

Little is known of the status of eelgrass beds on Togiak Refuge coastlines. This lack of comprehensive monitoring and seagrass mapping has resulted in the ability to detect only drastic habitat alterations rather than small yet ecologically influential changes (Thayer *et al.* 1975). However, monitoring methods such as aerial photography surveys and satellite photography have recently been used to detect change in seagrass distribution. Both methods successfully detected changes in area coverage of eelgrass beds in Izembek Lagoon, Cold Bay Alaska (Ward *et al.* 1997), and Bahia San Quintin, Baha California, Mexico (Ward *et al.* 2003). Because of the important role of eelgrass in the ecology and economy of the Bristol Bay region and the apparent global decline, Togiak Refuge has identified the need to collect baseline distribution data and implement future monitoring to ensure proper management of this important resource.

Objectives

1. Locate all eelgrass beds greater than 1 hectare in area along the Togiak Refuge coastline.

Study Area

Togiak Refuge, established in 1980, encompasses 4.2 million acres of land between Kuskokwim and Bristol Bays in southwestern Alaska and has approximately 600 miles of coastline. The Bristol Bay coastline is characterized by protected, shallow inlets and bays, with low turbidity. Hagemeister Island, located in southwest Togiak Bay and approximately 60,000 acres in size, may act as a protective barrier from inclement weather and decrease the effects of wave action on the shoreline. Northern Bristol Bay's tide level changes can be extreme, often experiencing fluctuation more than 20ft between low and high tide. The Kuskokwim Bay coastline is comparatively unprotected and can experience high turbidity, primarily at river entries into bays and lagoons. Chagvan Bay, in which occurs Togiak Refuge's largest eelgrass bed, is on the Kuskokwim Bay coastline. Kuskokwim Bay tide level changes often range from 10 – 12ft.

Methods

An aerial survey was flown along the Togiak Refuge's coastline to document the location of eelgrass beds. This flight occurred on 6 August 2004 using a Cessna 185, flying at an altitude of 300 ft above ground level at airspeeds of 80 mph. Observations were made by the pilot and one observer sitting in the front passenger seat.

After an eelgrass bed was located, the perimeter of the bed was flown and documented. Eelgrass locations were recorded on a moving map using ArcPad, and the estimated coverage of individual beds was created in ArcView.

Results

Twenty-three eelgrass and eelgrass - kelp beds greater than 1 hectare were identified on Togiak Refuge coastlines by aerial survey in August, 2004. (Table 1, Figure 1): eighteen on the Bristol Bay coastline and five on the Kuskokwim Bay coastline in Chagvan Bay, Goodnews Bay, and Security Cove. The largest continuous beds occurred in Chagvan and Nanvak Bays (Figure 2). Other large continuous beds were found in Hagemeister Straight, Toungue Point, Togiak Bay, and Ungalikthluk Bay (Table 1). Remaining smaller beds were continuous, but patchy in the outer reaches of the beds, or continuous and mixed with kelp such as in Metervik Bay.

On the day of the survey, visibility conditions were excellent. There was direct overhead sunlight, low wind, and no cloud cover, allowing for good visibility in all but turbid waters. High turbidity occurred at river outlets. The survey began at 1045 h in the Nushagak Bay coastline, and ended at Quinhagak at 1500 h on the Kuskokwim Bay coastline. The survey began 2 hours after the predicted high tide for the Clark's Point, Nushagak Bay coastline, and Kuskokwim Bay was surveyed 2 hours prior to the predicted high tide time for the entrance of Goodnews Bay. At the time each bay was surveyed, the Bristol Bay tide was decreasing, and the Kuskokwim Bay side had a rising tide. Eelgrass depth extent was observable during survey water levels. Bare ocean sediment was conspicuous between eelgrass beds and well before the water depth was too high to prevent sightability of the whole bed. However, in eelgrass – kelp beds, it was difficult to delineate the depth extent of eelgrass.

Table 1. Eelgrass bed location description on Togiak National Wildlife Refuge, 6 August, 2004.

Number	Location	Size (ha)	Number	Location	Size (ha)
1	Metervik Bay	53.26	13	Hagemeister Strait	61.69
2	Nunavachak Bay	13.32	14	Asigyukpak Spit	257.11
3	Nunavachak Bay	44.92	15	Hagemeister Strait	1268.77
4	Ungalikthluk Bay	469.78	16	Hagemeister Strait	35.81
5	Togiak Bay	69.60	17	Hagemeister Strait	36.93
6	Togiak Bay	13.19	18	Hagemeister Strait	70.66
7	Togiak Bay	4.94	19	Nanvak Bay	791.25
8	Togiak Bay	66.88	20	Security Cove	91.56
9	Togiak Bay	717.17	21	Chagvan Bay	2551.71
10	Tongue Point	1416.28	22	Goodnews Bay	42.85
11	Estus Point	58.22	23	Goodnews Bay	362.99
12	Estus Point	102.91			

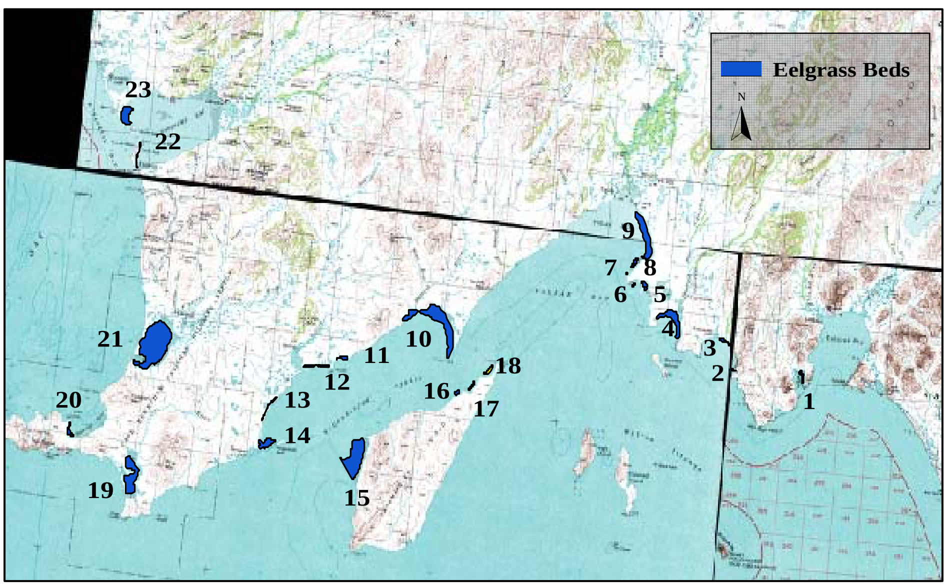

Figure 1. Observed eelgrass bed locations on Togiak National Wildlife Refuge, 6 August, 2004.

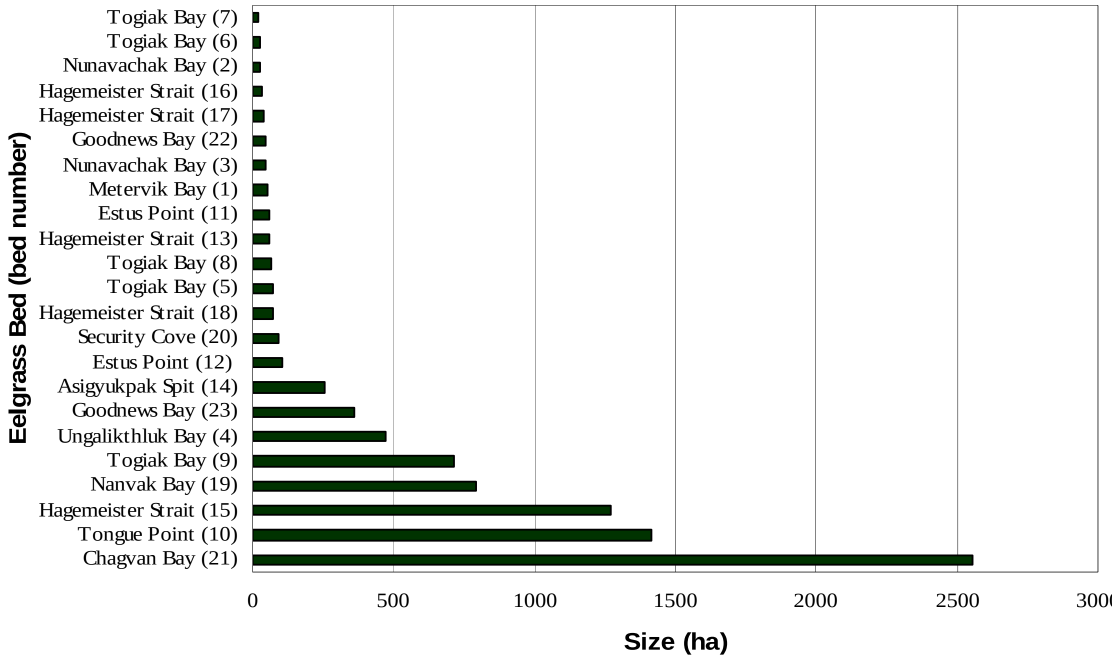

Figure 2. Eelgrass Bed Size (ha).

Discussion

Locations of eelgrass beds observed during the survey provide important information which will be utilized for planning future eelgrass distribution studies. Due to ideal weather conditions, the eelgrass beds observed are believed to accurately, though coarsely, represent the true distribution of eelgrass along Togiak Refuge coastlines. The preliminary survey was flown in direct sunlight with 0% cloud cover, and no winds. The weather resulted in low turbidity water conditions allowing for good visibility.

Although methods used for this reconnaissance survey were ideal for locating eelgrass beds, the information gathered is too coarse for use in long-term monitoring of the spatial distribution of eelgrass. Outside of photographic surveys, recording eelgrass bed size from an aircraft is difficult because delineating eelgrass bed boundaries is often inconsistent and imprecise form of measurement. Several methods can be used for long-term monitoring of eelgrass distribution and its corresponding area. Remote sensing techniques such as digital aerial photography and satellite imagery combined with ground truthing are the most accurate and applicable methods.

Aerial photography is a common method for estimating seagrass distributions. This method requires preparation to account for many variables. The following methods summarize the coastal monitoring program implementation guidelines developed by the National Marine Fisheries Service (Dobson *et al.* 1995). Flightlines for photography of study areas are designed with reference to aeronautical and nautical charts. Minimizing planned flightlines increases survey efficiency. Optimally, photographs would include shoreline landmarks in 33% of the image to properly georeference images. Additionally, at least 30% overlap of photographs is necessary to ensure contiguous coverage. A timetable of one to two months duration for surveys allows for optimal conditions for aerial photography. Atmospheric and water conditions also need to be accounted for. Cloud cover and haze should be nonexistent to avoid shadows during image collection. Turbidity in study area should be low. Image collection should be collected ±2 hours of lowest predicted tide. Extreme low tide is optimal. Eelgrass is more visible in photographs at low tide compared to other tide stages. Low tide also allows for deeper portions of eelgrass beds to become visible. However, low tide occurs at different times along the Togiak Refuge coastline, varying significantly between Bristol Bay and Kuskokwim Bay. This lag time must be considered during planning No wind is optimal for image collection, however, wind speeds below 10mph is within acceptable limits.

Satellite imagery provides images over large areas, and can be less costly when repeating procedures for monitoring than aerial photographs (Klemas *et al.* 1993). However, weather and atmospheric conditions create challenges for this method of data collection too. Much of the same weather conditions needed for aerial photography are also necessary for satellite imagery. Image collection dates must be selected in advanced, making planning for weather conditions more difficult, and may result in low quality image collection. It is necessary to conduct ground truthing of eelgrass beds for images collected through both satellite imagery and aerial photography. Ground truthing includes on-site collection of eelgrass samples to identify to species, and to incorporate species proportions into the distribution estimate.

Conclusion

Spatial distributions of eelgrass beds greater than 1 hectare were documented along Togiak Refuge coastlines during this survey. Locations collected during this survey should be used to compare aerial photography and satellite imagery monitoring methods. This comparison will ensure the efficacy of the design of a long-term eelgrass monitoring plan to quantify spatial change in the distribution of eelgrass over time along Togiak Refuge’s coastlines.

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