Using Multiple Methods to Gather Spatial Data on Human Uses of Rhode Island's Coastal Lagoons

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1. Introduction

Coastal managers are increasingly using marine spatial planning (MSP) as a tool to pursue ecosystem-based management for coastal shores and waters. The coastal margin is becoming progressively busier and this increased use raises concerns about the ecological and social carrying capacity of these ecologically, economically, and recreationally rich areas. Managing the coastal margin will require high quality spatial data. However, the quantity and quality of the biophysical geospatial datasets have typically been much better than those for human uses. Furthermore, monetary values have been quantified and mapped better than attitudes, particularly users' attitudes about other types of uses. This paper will report on an ongoing study on Rhode Island's coastal lagoons that utilizes and compares two methods for collecting geospatial data on human uses and attitudes about those uses. The methods utilized are (1) on-the-water visual surveys, utilizing GPS and range finders; and (2) participant intercept surveys with recreational boaters, coastal strollers, recreational bathers, and recreational shellfish harvesters. This paper will report on the strengths and weaknesses of each method and suggest methods for blending the results of these multiple methods to produce more nuanced attribute-rich spatial data on human uses and valuation of the estuarine environment.

2. Background

2.1 Rhode Island's coastal lagoons

The coastal lagoons along the south coast of Rhode Island are shallow, productive marine embayments separated from the ocean by barrier spits (Anthony et al. 2009). They provide important ecosystem and habitat functions for fin and shellfish and are important resting stops for waterfowl migrating along the Atlantic flyway (Jones and Phillips 2009; Ernst et al. 1999). Recreational users value the lagoons and their shores for a wide and growing list of activities such as fishing, clamming, sailing, kayaking, sunbathing, stand-up paddle boarding, wind surfing, kite surfing, motor boating, swimming, walking, and water tubing. The lagoons are also utilized commercially for activities such as fishing, clamming and shellfish aquaculture.

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In short, the demand to use the lagoons is diverse, high, and growing. In particular, oyster aquaculture has expanded rapidly over the last 15 years at an ever-increasing rate in Rhode Island. In 15 years, shellfish aquaculture in Rhode Island grew from a farm gate value of almost $315,000 in 2000 to over $5,000,000 in 2014. The growth of aquaculture on the coastal lagoons has been increasing rapidly, from 8.5 acres in 2000 to 87.35 acres in 2014 (Beutel, 2014). The number of lease proposals and the debate surrounding them are also increasing.

The Rhode Island Coastal Resources Management Council (CRMC) has the authority to issue aquaculture permits but must consult with the Department of Environmental Management (DEM) and the Marine Fisheries Council (MFC) for conflicts with wild harvest fisheries and the natural ecosystem (RIGL § 20-10-5).[1] Rhode Island law places a specific burden upon DEM to ensure that new aquaculture leases do not unreasonably interfere with other uses: "aquaculture should only be conducted... in a manner consistent with the best public interest, with particular consideration given to the effect of aquaculture on other uses of the free and common fishery and navigation" (RIGL § 20-10-1). Currently, the state had mandated that shellfish aquaculture shall not take up more than five percent of the surface area below mean low water of any coastal lagoon (RI CMP 300.11).

2.2 Missing social spatial data

DEM and MFC cannot efficiently fulfill their legislative mandates because they currently lack higher resolution spatial data on recreational and commercial uses of the lagoons and economic valuations based upon such spatially referenced inventories. For example, DEM has little information concerning the number of people recreationally shellfishing, the quantity of shellfish harvested, or the spatial distribution of recreational shellfishing effort, in part because there are no licensing or reporting requirements for state residents.

Historically, coastal managers have tended to regulate human activities in the marine environment on a sector-by-sector basis and with limited consideration of how different human activities interacted with one another in space. Thus, aquaculture, sport fishing, shellfish harvesting, boating, etc. would all be regulated more or less separately. More recently, though, coastal managers increasingly are utilizing forms of marine spatial planning (MSP) as a tool for pursuing ecosystem-based management (EBM) (Blaun & Green 2015; Koehn et al. 2013; Kidd 2012; Balaguer et al. 2011; Douvere 2008; Ehler

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[1] Of course, the potential for conflict between bivalve aquaculture and other uses is not unique to Rhode Island. As Peterson et al. (2010) noted:

> As traditionally practiced in the United States, bivalve mariculture relies heavily on nearshore waters that are under state or town jurisdiction. These nearshore locations … expose the mariculture operations to extensive use conflicts because the nearshore waters of the United States are heavily used for recreational and aesthetic purposes. (107).

2008). MSP could enable CRMC, DEM and MFC to better understand the potential positive and negative interactions of human uses of the coastal lagoons and thereby create long range plans for accommodating aquaculture and other human uses of these coastal lagoons while protecting or enhancing ecosystem functions. Currently, applications for different uses, including aquaculture, are dealt with on a case-by-case, piecemeal basis rather than through long-range, comprehensive planning.

One of the difficulties in implementing MSP has been the unavailability of high quality goespatial data of human uses and values. Gray et al. (2011) highlighted the gap between biophysical and social data, arguing that “[a]lthough biophysical processes are often well represented in spatial datasets, there is typically much less readily available data on human use of the marine environment” (286). Koehn et al. (2013) came to the same conclusion, stating “While there has been significant progress in research on biophysical and ecological attributes of ocean environments, to date there has been far less focus on social data in these systems, which has significant potential to inform and improve ecosystem-based ocean planning processes” (36).

While such inventory maps and valuations would be highly useful for planning purposes, they are also difficult to develop because human activity in coastal waters is spatially and temporally complex both ecologically and socially (Gray et al. 2013; Dalton and Thompson 2013; Thompson and Dalton 2010; Dalton et al. 2010). While different methods for mapping human use of the marine environment have been used, they all arguably have strengths and weaknesses. Consequently, this research utilizes and compares two methods (boat-based offset transect surveys and intercept surveys) to quantify, value, and map commercial and recreational uses on and along the shore of the coastal lagoons.

3. Methods

This research focused on the three larger lagoons along the southern coast of the state of Rhode Island: Point Judith, Ninigret, and Quonochontaug.

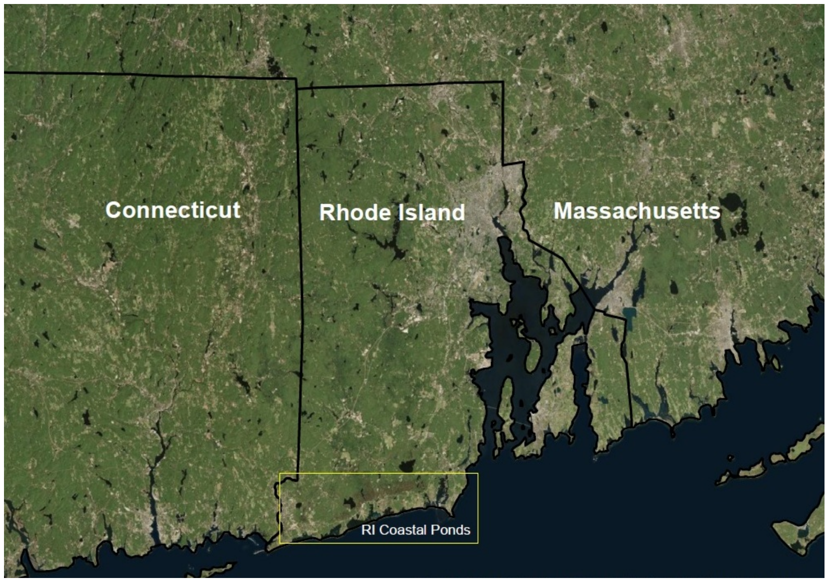

Figure 1. Rhode Island

Figure 2. South shore of Rhode Island - coastal lagoons

3.1 Boat-Based Off-Set Transect Surveys (B-BOTS)

Thompson and Dalton (2010) discuss how different methods for observing and mapping coastal activities have advantages and disadvantages, depending on the physical and regulatory characteristics of the study area. Due to their size and complex shoreline, the B-BOTS method is highly suitable for Rhode Island's coastal lagoons.

B-BOTS uses advances in GIS, GPS, and light ranging technologies to create a methodology that is derived from line transect sampling methods that were developed in the field of ecology over eighty years ago (e.g., Burnham et al., 1980) to take censuses of organisms (fish, birds, people) along a specified route. Researchers have used modified line transect sampling to record positions of recreational fishermen in a marine park in Australia (Lynch 2006) and to investigate relationships between distributions of marine mammals and human activities in a marine sanctuary off the northeastern U.S. (Wiley et al. 2002). Using similar methods, Sidman et al. (2000) recorded positions and associated attributes of recreational boats from stationary shoreline locations. Dalton et al. (2010) used B-BOTS to characterize the distribution and composition of vessels on upper Narragansett Bay and to demonstrate how composition changed in response to such factors as nearby land uses, cloud cover, and water quality. Thompson and Dalton (2010) used B-BOTS to study the distribution, intensity, and composition of shoreline access along Narragansett Bay and to demonstrate (among other things) that the intensity of shoreline access was not correlated to the density of public access points or the population density of the surrounding neighborhoods, but was highly correlated to the availability of parking. Thompson and Dalton (2010) also show how different user groups (fishers, walker/runners, and people sunbathing) distributed themselves spatially in different but predictable ways depending on the configuration of the available parking. Thus, geospatial data gathered by this method can be extremely useful when conducting social carrying capacity analyses.

In this study, researchers used a 17-foot Boston Whaler along with a Trimble GPS unit that is capable of sub-foot accuracy and Trupulse range finders. Transect lines were established for all of the lagoons that were surveyed, allowing for complete coverage of each lagoon and its shoreline. The dates surveyed and the order in which each transect line was run for each lagoon were determined by stratified random selection (see, Thompson and Dalton, 2010).

As the boat navigates the transect line using onboard GPS, a team member points range finders, which have a Class 1 (eye-safe) laser and a built-in compass at the boat or shoreline user. With the press of a button, the rangefinders transmit the distance and compass bearing via bluetooth to the Trimble handheld computer with built in GPS. The Trimble was loaded with ESRI's ArcPad, which is software for mobile GIS and field mapping. Starting with the coordinates of the Trimble GPS unit, ArcPad uses the distance and bearing measurements from the Laser Locator Binoculars to immediately calculate an "offset point" for the observed boat or person on the shoreline.

The research team utilized ESRI's ArcPad Application Builder to develop custom touch screen forms so that team members can quickly add attribute data to each recorded observation. As the button is pushed on the rangefinders and a record is created in the database, a data collection form simultaneously appears on the screen of the Trimble computer. The second team member, who is holding the Trimble, can then use a stylus and a series of dropdown menus to rapidly add attributes to each observation. The starting point for this preloaded attribute system was developed for Thompson and Dalton (2010) and Dalton et al. (2010). The system used widely available classification systems when possible. For example, the United States Coast Guard boat classification system was used. However, the researchers built on and modified this system through discussions with RISG, CRMC, and participants in the Shellfish Management Plan. The drop down forms were further modified based upon the early surveys.

Once the data has been gathered, the intensity of different uses can be analyzed in ArcGIS, using such techniques as density analysis, which is a technique that is particularly well suited for studying social carrying capacity in an open water setting (Beeco and Brown, 2013; see also, Sherrouse, et al. 2011). Spatially explicit use data of this type can be used to statistically analyze the correlations between a specific use and other uses, spatially regulated areas, and environmental factors (Smallwood et al., 2012; Dalton et al., 2010), which is extremely useful for marine spatial planning. Typical approaches to MSP use a blunt form of Euclidean zoning, where sharp lines are drawn (at least on paper, because boundaries are particularly difficult to discern in the marine environment) and a use is either included or excluded; any interaction is assumed to be too much. B-BOTS produces continuous surfaces of use intensity that can change with environmental and social conditions, allowing an opportunity to adopt performance-zoning guidelines that maximize utility while simultaneously reducing or avoiding conflict. The rich, high resolution social geospatial data produced by B-BOTS can be combined with both the environmental data that is collected during transects and the growing wealth of environmental geospatial data for the coastal lagoons that has been collected by natural scientists to further test the factors that influence human use of the marine environment and to construct the type of “what if” scenarios that are common place in land use planning.

3.2 Intercept Surveys

Researchers also surveyed users at access points on the three coastal lagoons at pre-determined randomly selected days and time intervals. In a given day, researchers went to three or four access points on a lagoon. Researchers asked every adult they saw using the lagoon for an interview. The first part of the interview asks the user to draw on a printed-out map of the lagoon where they went, where they spent the most time, and any locations that they avoided. They are then asked which activities they participated in on the lagoon that day, which activities they did at the place they spent the most time, and what they saw other people doing at the place they spent the most time. They are then asked to give their attitudes (5-point scale with 1=very negative to 5=very positive) toward the other uses they saw as well as some features of the lagoon (e.g., accessibility, noise, amount of people encountered). The users are also asked questions about their main reasons for going to the lagoon on that day, the importance of different weather features in their decisions, and how often they visit Rhode Island coastal lagoons.

4. Results: Preliminary comparisons

There are benefits and limitations to using different data collection and analysis methods. One of the important contributions of this study is the use of both observational (B-BOTS) data and intercept surveys to understand where people are using the coastal lagoons, how, when, and why. The two methods used to answer these questions complement each other in many ways. This paper will focus on intensity of use, rationale for participating in certain activities, and data resolution as three examples of the complementary attributes of these two methods.

4.1 Intensity of use

One important aspect of human uses of any area is the intensity of use. This is an area where participatory mapping through intercept surveys can fall short and observational methods can be more useful. As shown in Fig. 3 below, participants in the intercept surveys drew rough boundaries indicating where they spent the most time that day on the water. It is possible that throughout the day they traversed the entire area that they indicated on the map but spent considerably more or less time in different parts of that area. The appearance of the map may suggest high use in the entire area indicated when, in reality, use was not uniformly distributed throughout the area. Continued systematic observation and mapping of the uses of a lagoon can show which areas are used most intensely. Mapping intensity is one of the benefits of the observational data collection method.

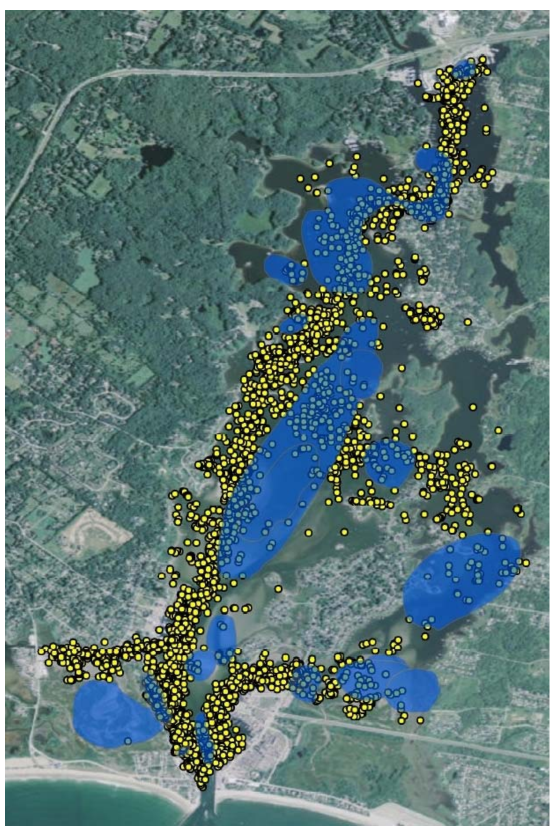

Figure 3. Pt Judith Lagoon. Blue areas are reported use, yellow are observations of use

4.2 Rationale for participating in certain activities

As noted in the above section, one of the strengths of the B-BOTS method is a more accurate picture of the intensity of use of certain areas of the lagoons. This is important information for planning, however the data do not provide a clear explanation for why certain areas of the lagoons are used more heavily than others. B-BOTS data can be compared with other spatial characteristics, like access points and depth, to better understand why people might use certain areas, but the B-BOTS data alone are not sufficient to explain human behavior. Other factors, like attitudes, values, beliefs and norms, can provide additional insights about why people use certain areas for particular activities; lagoon data from the intercept surveys can provide this additional information. When mapping during the intercept surveys, users explain why they choose certain areas over others or why they avoid some areas. Users are also asked in an open-ended format for some of the main reasons for choosing to come to the lagoon that day. Data are also collected about where the user came from, how far they drove, and how often they visit the lagoon. This data helps researchers understand the rationale behind people's decision making to use the lagoon. This also allows researchers to understand how people might respond to environmental and policy changes in the future. A deeper understanding of the attitudinal factors influencing human behaviors is one of the benefits of the intercept surveys.

4.3 Resolution: Temporal and Spatial

Participatory mapping during the intercept surveys can also have limitations when there are multiple uses in one area. For example, a static map of a lagoon showing where users indicated different uses might suggest that there are multiple areas of conflict. For instance, someone might use an area to dig clams and someone else may say they use that same area to water ski. These uses might seem incompatible but, in actuality, the shellfisherman likely only uses the area at low tide and the water skier likely only uses it at high tide, effectively sharing the same space but at completely different times. The B-BOTS data is collected by the hour and correlated with tidal information, helping to delineate the temporal patterns of use on the lagoons.

The higher resolution spatial information collected with the observational data is also an important strength of the B-BOTS method. Before approving an aquaculture permit, RI CRMC must determine whether an area proposed for an aquaculture lease has existing uses that would be incompatible with aquaculture activities (RI CMP 300.11). As seen in lagoon Fig. 4, the pink dots represent recreational shellfishermen and the green rectangles represent aquaculture lease sites on the lagoon. The leases must be carefully plotted in order not to interfere in a significant way with other uses. High resolution spatial data is important for these decisions and is one of the benefits that observational data collection method provides.

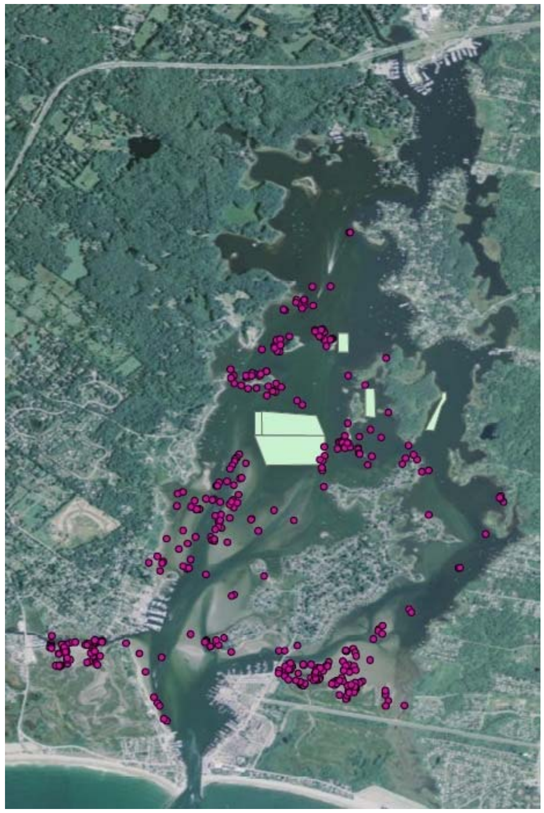

Figure 4. Pt. Judith. Green shapes are aquaculture leases, pink are observed recreational shellfishermen

5. Conclusion

The two methods used in this research each have unique benefits and limitations that, combined, complement each other to create a more complete understanding of where humans are using the lagoon, what they are doing, and the reasons for their actions. The blend of these two methods is ideal for marine spatial planning, especially in areas of dense use. This information, combined with biophysical data, is important for determining ecological and social carrying capacities in the coastal lagoons in Rhode Island.

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