Casco Bay Estuary Project/Maine Department of Marine Resources

Casco Bay Marine Resources
GIS Map Verification Project

Christopher S. Heinig
MER Assessment Corporation

&

Andrew Bertocci
AlgaeTech Seaweed Solutions

September 30, 1997

Acknowledgement

We wish to express our thanks to Seth Barker, head of the Maine Department of Marine Resources' GIS Office, for providing the GIS maps and other related materials needed to carry out this project, taking the time to join us in the field to review field-check procedures, and providing guidance and suggestion through the course of the project.

Similarly, we wish to thank Katherine Groves, Director of the Casco Bay Estuary Project, for providing administrative guidance for the project and joining us in the field to gain first-hand appreciation for the nature of the project.

Special thanks also go to Joe Payne, BayKeeper, and the other staff members at The Friends of Casco Bay who assisted in the field surveys of Peaks and Long Islands and Great and Little Diamond Islands.

Finally, we wish to thank all of the individuals who gave freely of their time and knowledge during the Interview phase of the project. They are: Dana Wallace, Brunswick; Alan Houston, Brunswick; Kim Payne, Westbrook; Peter Angis, Scarborough; Edgar "Ted" Curtis, Yarmouth; Clinton A. "Ken" Goodenow, Freeport; Bradford Varney, Freeport; Richard Lemont, Phippsburg; Gene Graffam, II, Harpswell; Russell Coffin, Harpswell; Jon Hentz, Georgetown, West Bath and Phippsburg Warden; Donald Card, MDMR; Mick McGivaren, Freeport; and Thomas Bennett, Freeport

This project was funded in its entirety by the Casco Bay Estuary Project (CBEP) through the New England Interstate Water Pollution Control Commission (NEIWPCC) with funds provided by the U. S. Environmental Protection Agency, (USEPA).

Consistent with Federal Policy, this document is printed on Recycled Paper

Table of Contents

Introduction

A brief history of bivalve shellfish distribution mapping along the Maine coast

The available map-based information on species distribution of molluscan shellfish in Casco Bay and other coastal areas in Maine is based primarily on a mapping effort that was a joint undertaking of U.S. Environmental Protection Agency (USEPA) and Maine Department of Marine Resources (MDMR) in the mid-70's (USEPA and MDMR, 1976). The result was a series of maps for the coast at a scale of 1:48,000 that were the basis for the shellfish component of Maine State Planning Office, Maine Coastal Inventory (MSPO,1977).

Since that time, several surveys directed at determining the stock levels of certain species have been carried out. In 1978, Maritec surveyed blue mussel, *Mytilus edulis*, stocks from the Damariscotta River to Machias Bay (check date and extent), Heinig and Tarbox (1985) surveyed European oyster, *Ostrea edulis*, stocks in the eastern portion of Casco Bay, and there have been numerous surveys for soft-shelled clam, *Mya arenaria*, management.

The Maine Coast Inventory maps covered the entire Maine coast, were also at a scale of 1:48000, and had two series that portrayed information on fish and wildlife. Bivalve shellfish distribution was shown in the series titles Fish and Wildlife 2. The handbook documenting these maps refers to information on the distribution of specific bivalve shellfish, commercial sea urchins, flounder, marine worms, and herring as coming from Department of Marine Resources coastal wardens, on the basis of their working knowledge. Additions were made by other Marine Resources personnel and by coastal fishermen and residents. The primary source of information for bivalve shellfish appears to be identical to that used in the USEPA and MDMR, 1976, as the same areas are mapped in a very similar fashion.

Additional mapping of shellfish species distribution was done as part of *An Ecological Characterization of Coastal Maine*, U.S. Fish and Wildlife Service (USFWS), 1980. This publication includes extensive documentation on what was known at that time about the coastal region between Cape Elizabeth and the Canadian border and used the USEPA and MDMR maps of 1976 as a basis of the mapping for bivalve shellfish distribution. These 1980 maps of bivalve shellfish areas were recompiled on a 1:24,000 orthophoto base. Other mapping efforts include Heinig and Tarbox, 1984, for European oysters in eastern Casco Bay, and Maritec, 1978, for mussels in the area from the Damariscotta River to Jonesport.

An Ecological Characterization of Coastal Maine was used as the primary sources of manuscripts for the digital representation of bivalve shellfish distribution for oil spill response. These maps were compared for accuracy with the original USEPA and MDMR, 1976, maps. Where differences were found, the original maps were used as the source and corrections made on the 1980 manuscripts. Portions of the coast not included in the 1980 publication were digitized from manuscripts derived from the original 1976 maps. This file is available from the Maine Department of Marine Resources in an Arc/Info export format and is distributed by the Maine Office of Geographic Information systems (GIS). Other formats are available on request.

Project Background

The first exposure to Geographic Information System (GIS) maps in the Casco Bay region occurred in the early 1990s as the joint USEPA/State of Maine Casco Bay Estuary Project (CBEP) began working with local communities and encouraging a watershed approach to the protection of Casco Bay and the management of its resources. Considerable effort was placed on developing GIS maps of the entire watershed, but smaller projects were developed to focus on specific communities, partly as demonstration projects. The Town of Harpswell, in the mid-eastern section of the Bay, was one community selected for GIS demonstration. Several parameters were identified for mapping. Since the Town was beginning to work on an Enhanced-911 program for rapid identification of emergency situation locations, roads became one focus. The Town of Harpswell also had a long-standing interest in its shellfish resources and the areas closed to shellfishing as a result of residential overboard discharges and other pollution sources. Consequently, the GIS maps showing the location of these contamination sources and the associated MDMR National Shellfish Sanitation Program (NSSP) sampling sites became very important tools in the efforts to identify and correct the contamination sources to increase the area available for harvesting shellfish, particularly the soft-shell clam, *Mya arenaria*.

By the mid 1990s, as GIS maps began being used more and more to present information to town residents and their municipal officials, the power of this tool became increasingly evident, not only to the presenters, but to the audiences as well. Important, far-reaching decisions were now being made by communities based on the information displayed on these maps. As the extent and importance of these decisions increased, it became clear that the usefulness and worthiness of those decisions were directly dependent on the accuracy and completeness of the information depicted on the maps.

The Casco Bay Estuary Project showed its specific interest in the soft-shell clams of Casco Bay in 1993 when it commissioned a study of the *Mya* resource and associated industry . The final report, titled *Economic analysis of the soft-shell clam, Mya arenaria, industry in Casco Bay - Final Project Report*, (Heinig et al., 1995) presented several recommendations for the enhancement of the resource and improvement of its management. Two of these recommendations were:

- The boundaries of the shellfish habitat should be clearly defined for both open and closed areas to allow detection of any changes which may occur in the habitat over time.

- The boundaries of the area *actually populated* by clams should be clearly defined for both open and closed areas to ensure accurate stock assessment and allow detection of any future expansion or retreat of the population

This project responds, at least in part, to these recommendations.

Project Purpose

As stated above, much of the shellfish habitat and resource distribution data represented on the current GIS maps date back to 1976 or 1980. The purpose of this effort is to compile and review more recent information on shellfish habitat, population distribution, and harvesting effort to allow improvement of the currency of the data represented by GIS maps. To meet this purpose, the project was divided into four (4) primary task:

1. ***Photo-interpretation of major features*** - aerial photographs of the Casco Bay area and the existing MDMR GIS maps were compared to identify any major discrepancies between the two. All major discrepancies were noted for field checking at a later date under Project Task 3.

2. ***Interviews*** - individuals familiar with Casco Bay's shellfish industry history and commercial harvesting of shellfish resources were interviewed on an individual basis to develop specific information on a flat-by-flat basis. Information sought included: productivity, past and present; extent of population distribution, past and present; sustainability, *i.e.*, reliability of annual recruitment, changes in population distribution, past and present; overall rating compared to other Casco Bay flats. Quantitative information was solicited, although it was understood from the outset that only qualitative information might be available.

3. ***On-site field checks*** - discrepancies in major features noted in Project Task 1 and information of specific interest collected in Project Task 2 were verified through on-site field checks. Field checks were used to verify the existence, location and size of major physical features, *i.e.* bedrock outcrops (ledges), mussel bars, certain eelgrass beds, etc. Differentially corrected Global Positioning System (D-GPS) was used in the field, where applicable, to accurately establish the locations, as well as dimensions, of major physical features.

4. ***Methods and Materials Report*** - a final project report, *this report*, will provide a detailed explanation of the background and purpose of the project, as well as a description of all materials and methods used in carrying out the project to allow duplication or modification of the process used here along other portions of the coast of Maine.

Project Products

The work carried out under this project was to result in the following task-specific products:

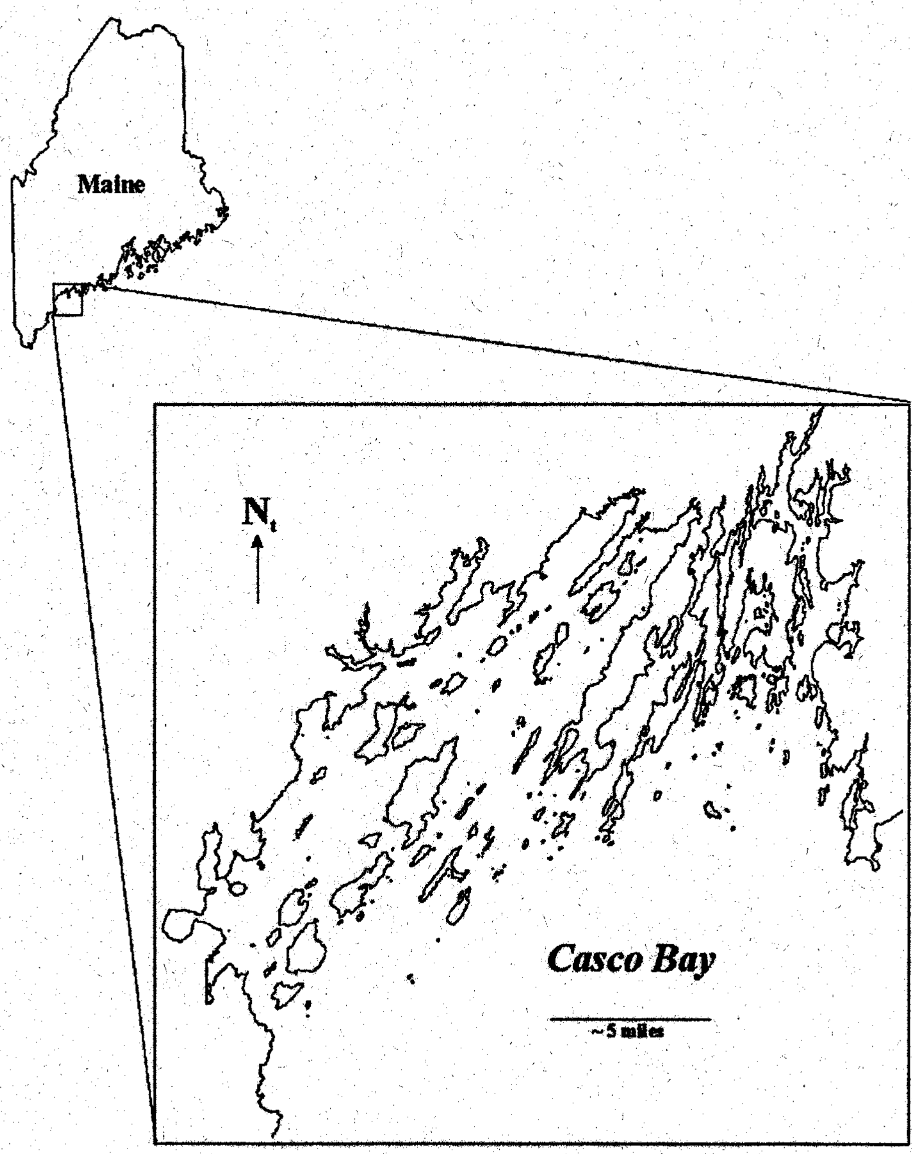
Task 1. Annotated, laminated GIS maps (1:7,000/1:6,000 provided by MDMR) showing discrepancies; referenced discrepancies notations;
Task 2. Written interview summaries, including data quality rating; annotations on laminated GIS maps;
Task 3. Finalized laminated GIS maps showing all notations, changes to location and/or size of major physical features; tabulation of checked major physical features and GPS coordinates;
Task 4. Written report with attachments of or references to the products of Project Tasks 1-3.

Materials and Equipment

Maps

The geographic area covered by this project extends the full length of Casco Bay from Cape Elizabeth to Small Point (see Figure 1., below).

Figure 1. Project Geographic Area
Casco Bay, Maine - Cape Elizabeth to Small Point



Forty-two (42) sectional GIS maps (refer to the Appendix, Index Map, note red numbered maps) measuring approximately 34 by 39 inches at a scale of approximately 1:7,000 were printed by Seth Barker, head of the MDMR GIS office, who provided technical and administrative oversight for this project. The area covered by each map, (shown by the example black rectangles around Maps # 3456 and #3176 on the Index Map in the Appendix), was slightly greater than 50% of the adjoining map in the grid series, thus providing overlap coverage of every-other map in the entire series.

These maps depicted principally geological information, *i.e.* sediment composition of the Bay, with distinction noted between intertidal and subtidal sediments and features. Limited biological features were also depicted, including eelgrass beds, algal flats, mussel bars, and seaweed communities. A map legend of these geological and biological features with associated alpha-numeric geological codes is shown in the Appendix, Geological and Biological Features Color Legend.

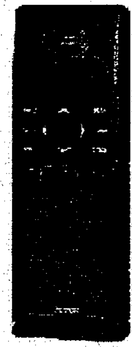
The maps were laminated for use in the field and to allow annotations to be made directly on the maps. Due to their size and number, however, the normal single-pass lamination process proved far too expensive (~$130/map). Fortunately, a laminator was found who was able to use a double-pass lamination method whereby over-sized paper is folded in half, laminated, the seams cut, the paper folded in the opposite direction, and the second side laminated For single, one-sided applications, this would effectively seal the entire page, however, to economize on the lamination costs, maps from opposite ends of the Bay were placed back-to-back and laminated together. Unfortunately, by doing this, the need to cut seams in the double-pass lamination process left the edges of the maps partially unsealed and consequently subject to delamination and water damage. This problem was solved by taping all of the edges with clear packing tape. The final product proved to stand up well in the field, allowed easy, permanent annotation with indelible markers, yet allowed corrections to be made by erasing marks with Isopropyl alcohol. Total cost for all maps was ~$260, or ~$6.00-6.50/map.

Several 8½"x 11" color copies of the Geological and Biological Features Color Legend, backed with the tide tables for the months in which the fieldwork was carried out, were laminated with heavy plastic to serve as field references in determining appropriate labeling of geological features.

Aerial Photographs

Two series of aerial photographs were used for the initial verification of accuracy of the map representations. Series A5085 Flight lines 22 through 33 were taken on 22 August 1993 during an astronomically low tide measuring -0.82 ft. at 0901 EDT and covered the area from Broad Cove, Cumberland to Cundy's Harbor, Harpswell. Series A5216 Flight lines 30N/S through 41 were taken on 12 August 1994 at an astronomically low tide measuring -0.55 ft. at 0912 EDT and covered the area from Cape Elizabeth, Cape Elizabeth to the south and the western Fore River, South Portland to the west to Cape Small, Phippsburg to the east (refer to the Appendix, Aerial Photo Index Maps). Both series were produced at a scale of 1:12,000 using Kodak Aerochrome Film and printed on Kodak Kodabrome II RC paper by James W. Sewall Co., Old Town, Maine, 04468 and were furnished by the Maine Department of Marine Resources for this project.

Global Positioning System (GPS)



A handheld Garmin 12 XL GPS unit connected to a MER Assessment Corp. designed and constructed differential correction (D-GPS) backpack module was used in the field to determine geographic position The D-GPS backpack module consisted of a molded plastic box with a clear, watertight removable cover containing a Garmin GBR-21 differential correction beacon receiver adapted with a Shakespeare model 173 Loran-C antenna and powered by a 12V 4.0 Ah lead-acid rechargeable battery. When using the D-GPS function and receiving the BNAS, Brunswick, Maine tower at 316.0 KHz, position accuracy was usually ±22-33 ft.

Methods and Results

Photo-interpretation of major features

As noted previously, initially, the purpose of this task was to identify any *major* discrepancies between the relatively recent aerial photographs of the Casco Bay area and the existing MDMR GIS maps. However, after beginning the photo-interpretation process and following the first interviews, it became clear that photo-interpretation was a more effective and efficient method of detecting discrepancies and determining the accuracy of the depicted information than the collection of anecdotal information through interviews. Consequently, the time allotted for interviews was reduced and the time allotted for photo-interpretation increased allowing for greater scrutiny of the photos and more detailed correction and annotation of the maps.

Photo-interpretation of major features was done with the aid of a fluorescent mag-light. Detailed interpretation was done with a "side-light" magnifying lens or a combination of the two. Individual photographs were reviewed and any discrepancies noted on the corresponding maps using indelible markers. The time lapse between successive aerial photos results in significant overlap between photos and individual features usually appear on at least two photographs but at slightly different angles. These different perspectives often reveal details that would otherwise be difficult to detect for a number of reasons, *i.e.* shadowing, reflection off of the water, surface disturbance, etc. Consequently, at least two photographs, (and occasionally three), were reviewed simultaneously for details of specific features.

As a first-time effort, it was uncertain how long the photo-interpretation phase of the project might take and the level of detail that might be achieved. Consequently, the level of scrutiny was prioritized to insure that all major features, at very least, would be covered; successively lower priorities were given to smaller items of lesser importance.

Highest priority in the photo-interpretation task was given to finding gross errors or omissions, principally geological in nature. These ranged from the obvious, such as misidentified areas, *e.g.* island land masses erroneously coded as eelgrass beds, to more subtle errors, such as large, shallow, subtidal areas having been misidentified as intertidal mudflats.

Second priority was given to correction for gross natural changes which had occurred since the baseline aerial photographs had been taken in 1966, *e.g.* substantial changes in eelgrass coverage, occurrence/disappearance of large mussel beds, areas of sediment deposition/erosion, etc.

Finally, third priority was given to relatively minor changes in geological and biological features, *e.g.* small pockets of sand, small intertidal flats between ledges, small clusters of eelgrass, minor changes in mussel bar configuration, etc.

A remarkable number of these feature changes, even minor ones, could be fairly accurately discerned through photo-interpretation. On occasion, however, even after carefully scrutinizing numerous photos at various angles, some areas still could not be categorized with certainty and these were scheduled for field verification (see following On-Site Field Checks section).

Interviews

Prior to beginning the interview phase, an interview form was developed in an effort to standardize the questions asked during interviews and the format in which collected information was reported (refer to the Appendix, Interview Form). All persons interviewed for the project are listed in the Appendix, Interview List.

Separate, individual interviews were conducted with each person. Each was asked to provide general information about the specific area he was most familiar with and to review the GIS map(s) of that area to determine if, in his opinion, any errors or omissions were apparent. Each was then asked to provide more detailed information regarding the shellfish resources of his area, *e.g.* productivity of specific flats (current as well as historical), reliability/repeatability of production, harvesting effort, etc. Scales of 1-5 were developed to rate the various responses in order to allow "mean" values to be ascribed to each area.

All who were interviewed were surprisingly free with their information and eager to assist. However, it became immediately obvious that the responses did not fit the standardized interview form nor the data collection format.

First, interview responses to specific questions were usually general or vague statements. For example, when questioned about the productivity of a specific flat more often than not the response was "It depends on the year." or "Last year it was productive, but it's not always." or "It goes in cycles." or some other qualified statement. None appeared prepared to make definitive statements about any given area. As an alternative, the respondents were asked to simply outline on the maps (in red indelible marker to distinguish these annotations from the photo-interpretation annotations in black) those areas they knew were productive within specific flats. Although willing to do this, there was still reluctance to rate areas with respect to productivity. Respondents had a tendency towards circling or otherwise indicating large areas within a bay or cove using descriptions such as "There's lots of clams all along this shore." or "This whole flat was loaded with clams."

Second, terms such as "productivity", "reliability", and "lots" are very subjective. What one digger may consider highly productive may be only moderately productive to another. Similarly, to some, reliable production may mean being able to return to the same flat, or even a specific area within a flat, year after year, while to others, reliable production may mean being able to return every second or third year. This variable, subjective interpretation of terms made *standardization* of responses nearly impossible. Therefore, instead of recording responses on the standardized interview form, interview comments were recorded by the interviewer with much of the information recorded directly on the map(s).

Although the interviews were both enjoyable and instructional, the information obtained through this process did not meet the level of detail and specificity necessary to achieve the goals of the project. Consequently, less emphasis was placed on conducting interviews and greater emphasis and time was placed on photo-interpretation and on-site field checks.

On-site field checks

On-site field checks were conducted throughout the Bay at areas where photo-interpretation did not allow features to be identified with certainty. Field checks were carried out from shore, by boat, and by helicopter. In each case, the date, time, and tide for the period were noted on the study area map.

Shoreside field checks

Field checks were conducted from land at sites on the mainland where access was available, particularly public access, *e.g.* Winslow Park, Freeport. Vantage points offering the widest view and best perspective of the area, such as knolls, bridges, and buildings, were selected.

Boat/airboat field checks

Islands, sections of the mainland where access was otherwise difficult, and subtidal features, such as partially submerged ledges, eelgrass beds, and seaweed communities, were surveyed by boat. Boat surveys were also useful to determine whether certain areas were intertidal or subtidal (at mean low water) and verify sediment types of shallow, subtidal areas. Boat surveys were usually restricted to the two-hour period just before and just after low water. An on-board depth finder was used to determine depth along transects perpendicular to the shoreline to estimate, by correction of depth by time before or after low water, the boundary between intertidal and subtidal areas.

Certain expansive intertidal areas or very shallow subtidal areas cannot be efficiently surveyed by boat. Such cases would require grounding the boat for extended periods of time, thus limiting the area covered during any given tide. Although not yet used by the time of this writing, additional field checks are scheduled as part of this project that will utilize the Town of Brunswick Maine Resources Office's airboat. Airboats are particularly well-suited for low tide work, for they operate effectively over water of any depth as well as across mudflats. Use of the airboat will maximize time spent in the field by allowing large areas to be covered in relative short time.

Helicopter

Certain features, such as mussel bars or beds and expansive areas of eelgrass can be assessed and surveyed best from a high vantage point. Where near-shore hilltops or buildings are not available as vantage points, the air is the only alternative. Fixed wing aircraft could be used, but they are of limited use in applications where a fixed vantage point is needed. Helicopters offer the advantage of increased maneuverability and the ability to hover over an area at nearly any altitude, from a few feet to several hundred feet.

A small, two-person helicopter was used in this project to survey five specific, complex areas: 1. the mouth of the Royal River up to Flying Point, 2. the upper Middle Bay area in the vicinity of White and Scrag Islands, 3. Harpswell Cove and adjacent areas, 4. the Gurnet and upper New Meadows River, and 5. the Strawberry Creek-Uncle Zeke Island area.

In the interest of maximizing the time spent aloft, all of the survey areas were video taped using a Nikon VN-750 camera and Hi8 format professional, edit-quality metal evaporated tape. The camera was set on Auto-focus/auto-exposure with "stable-shot" on to compensate for the vibration of the aircraft. Voice markers were used to identify the specific survey areas and to add commentary.

Two filming angles were tested: 1. near-vertical, and 2. oblique. The near-vertical images reduce glare and provide remarkable detail of both exposed and shallow, submerged features. However, as a vertical image of intertidal and subtidal areas, no landmarks are included in the image upon which to estimate location. The oblique angle images still provide considerable detail, but allow inclusion of shoreline landmarks to facilitate orientation and determination of location. Glare and reflection can be problematic when shooting into the sun, but this can be easily overcome thanks to the maneuverability of the helicopter.

The ability to drop to within a few feet of the water or mudflat and hover for up to several minutes is very helpful when attempting to collect detailed information, *e.g.* identifying specific types of seaweeds and algae or determining the coarseness of sediments, details which could not be obtained using fixed-wing aircraft, even if flown at low altitude.

Clam population boundary delineation

As a start towards responding to the second recommendation of the *Economic analysis of the soft-shell clam, Mya arenaria, industry in Casco Bay* report - to clearly define the boundaries of the area *actually populated* by clams on mudflats - recent municipal shellfish population surveys are being reviewed. Where population distribution data has been presented to allow determination of these boundaries, *i.e.* data is tagged to plots and plot locations mapped, an attempt will be made to establish these boundaries on the appropriate maps. This is possible for Freeport and Harpswell and several areas around the Bay surveyed as part of the CBEP economic analysis project.

At selected sites, the populated area boundary will be established by observing the flats and collecting geographic points (latitude and longitude) every 50-100 ft. along the boundary as "waypoints" using the backpack mounted D-GPS unit.

Discussion

Maps

As stated earlier, the primary goal of this project was to compile and review more recent information on shellfish habitat, population distribution, and harvesting effort leading to the correction of the existing GIS maps. The secondary goal was to develop and test a simple, yet effective, methodology to verify GIS mapped resource information that can be readily reproduced elsewhere.

All of the photo-interpretation corrections to the GIS maps, particularly those relating to shellfish distribution, have been annotated directly on the laminated maps, as have the field observations. These annotated maps will serve as the principal products of this project responding to the primary goal. This document responds to the second goal and serves to report on the methodology used.

The methodology used in carrying out the project has already been described above, but several possible modifications that might improve the process are worth mentioning.

As mentioned previously, the maps were printed such that there was some degree of overlap between them. This overlap is necessary to avoid having to annotate right to the edge of maps. The amount of overlap was fairly consistent on most of the maps printed for this project. However, in certain cases, the amount of overlap was excessive and the same area appeared on several maps. This led to a certain amount of confusion when reviewing maps, particularly towards the end of the project when inventory was being taken to ensure all areas had been completed. An overlap of 2 or 3 inches between all maps would be sufficient to ensure full coverage while avoiding confusion.

Laminating the maps to protect them from the elements and allow direct annotation with indelible marker (but retaining the possibility of correction) is effective and efficient. Laminating maps back-to-back reduces both cost and the number of individual maps one has to deal with. The idea of putting maps of different areas of the Bay back-to-back was based on the prospect of being able to put maps of one region side-by-side to view an entire area. Indeed, this allowed us to view the western and eastern regions of the Bay separately, but in their entirety. However, there was little call for viewing entire regions and having different regional maps back-to-back created serious problems when two surveyors wished to be in the field simultaneously working in different parts of the Bay. To alleviate this problem, back-to-back laminations should still be used, but maps for the same area of the Bay should be backed together. This being said, there are occasions where multiple copies of maps of selected areas is desirable.

Complex areas, *e.g.* those having numerous, different features, often required considerable correction during photo-interpretation, but also required considerable field checking. In these cases, the use of a single map resulted in excessive annotations on a single map. It would therefore be preferable to use at least two separate copies of the maps for such areas, one for photo-interpretation corrections and the other for field check notations.

Interviews

The idea of including anecdotal information provided by individuals familiar with the area and resources is laudable and certainly adds another dimension to the overall database. However, our experience suggests that this type of information is quite general and qualitative in nature and is consequently difficult to integrate with the specific, precise, and detailed information developed through photo-interpretation, field checks, and shellfish surveys.

One possibility for integrating these data is to find a way(s) of turning qualitative information into semi-quantitative data. For example, one Clam Warden interviewed described areas as " Two and a half bushel areas" or "Four bushel areas.", describing the amount a commercial digger could harvest in a normal tide. This approach appeared late in the process and could not be tested on any harvesters. However, one might use this type of rating system from the outset to determine if harvesters can relate to such images. Regardless, if anecdotal and more quantitative information are to be integrated, the methodology for accomplishing this should be understood early in the process. Furthermore, the interview structure should be designed around the way the results are to be used. For example, if the interview results are to be combined with current surveys of an area, the survey area should be clearly defined and annotated on the map prior to interview time. Then, for example, when asked "How about the area between Fogg Point and this outcrop of ledge *right here*?", a harvester will be able to give more specific information because the scale is smaller and limited to the digging area he/she is most familiar with between these to points. These historical data, combined with more recent survey data, where available, can be used to determine long-term trends.

Our experience also revealed that municipalities often have difficulty locating shellfish- related data. Since municipal shellfish committees are usually charged with conducting surveys and compiling shellfish-related data, documents relating to shellfish stocks are often kept by individuals rather than at municipal offices. Consequently, such documents are often difficult to obtain and should therefore be requested early in the process.

Field checks

Although considerable information can be gleaned from the photo-interpretation process, field checks is "where the truth be known". Going about field checking geological and biological features is fairly straight forward, but again, there are a few things worth bearing in mind.

Obviously, astronomically low tides offer views of subtidal areas rarely exposed or even visible at normal tides, much less neap tides. Every effort should be made to include these tides in the field checking schedule. Unfortunately, most astronomically low tides occur either during the night or early morning hours, or at dusk or early evening hours. The angle of light at these hours is oblique and usually does not penetrate deep enough to allow a clear view of the bottom and can cast shadows. Additionally, astronomical tides often mean bad weather.

Even during normal tides, particularly those occurring near mid-day when the sun is directly overhead, thus offering a clear view of the bottom to some depth, numerous observations will be made that need to be noted on the maps. In order to distinguish the corrections made during photo-interpretation and actual field verified features, it is preferable to make the latter notations in a specified color, different from all other notations. These notations should include the date, time, and somewhere within the area checked, the time and height of tide for the date.

Although no difficulties were encountered during this project, crossing private property can sometimes be tricky when conducting surveys of this kind. If a shoreside field checks schedule is prepared ahead of time and time allows, it may be advisable to provide homeowners and/or landowners prior notification that a survey crew will be working in their area. Cards giving general project information and a phone number of a project contact might be made up to be left on private property as a courtesy during land-based fieldwork.

A couple of comments on the legend, and how it is applied both in the field and on the maps, should be made. First, to the uninitiated, non-geologist, it may be difficult to identify a particular sediment type, *e.g.* "What is a 'boulder ramp'?", or to distinguish between a "mixed sand + gravel beach" and a "gravel beach". Similarly, it may be difficult to decide how to identify an area of mixed features, such as a boulder beach with coarse-grained sandy patches and gravel. Although a written description of each sediment type is available, one possibility for additional instruction might be to make photographs of typical geological and biological features available for study. Development of a photographic key that includes all geological and biological features, along with the individual technical description, alpha-numeric code, and mapping color code, might be worth considering.

With respect to map colors, some difficulty was encountered in distinguishing related features having similar, at times nearly indistinguishable, color codes. For example, the codes for "algal flats", "eelgrass", and "seaweed community" are, appropriately, all different, but very similar shades of green. Indoors, with artificial light and magnification, the distinction between these shades can be made fairly readily. However, without magnification, and particularly in the field with bright sunlight, distinguishing these shades is very difficult. The problem is further complicated by the fact that all three of these biological features often occur together or in close proximity to one another, *e.g.* an intertidal algal flat may give way to a subtidal eelgrass bed in what may appear as a contiguous mass of "green". The obvious solution is to simply change the colors, but consideration might be given to selecting strongly contrasting colors for similar features. An excellent example of features found together, but currently having strongly contrasting codes, are intertidal mud flats (bright yellow) and mussel bars (purple). Although these two occur naturally side-by-side, on the maps the mussel bars stand out sharply from the flats.

Finally, a brief comment on helicopter surveys. Normal rates for helicopters range between $100-200/hr. At first, the suggestion of using a helicopter may sound extravagant. However, based on a single experience with low-velocity, variable altitude surveys, the time spent in a helicopter is far more cost-effective than on-site ground surveys. During a 1½ hour flight, five complicated areas were thoroughly covered by video. An estimated 3-4 additional hours would be required to analyze a video recording of that length, bringing the full review time to approximately 4-5 hours. By comparison, surveying the same areas on the ground would require at least one full low tide per area, thus five field days at 3-4 hours per day, or nearly 15-20 hours. Our experience suggests that the hours saved may be better spent doing additional photo-interpretation or field checks where close-proximity observations, *e.g.* grain-size assessment, are required.

Conclusions

- Photo-interpretation is an efficient and cost-effective method of identifying both geological and biological features to a high level of detail, detecting discrepancies between aerial photos and maps, and determining the accuracy of the depicted information.

- Use of a "double-pass" lamination process to laminate large maps yields a water-resistant product that allows direct annotation and can therefore serve as a "corrected" final product.

- Direct involvement of the shellfish industry, both harvesters and managers, is vital to any project of this type, for it enhances credibility within the industry and consequently its acceptability and usefulness.

- Our experience suggests that anecdotal information developed through the interview process is quite general and qualitative in nature and is consequently difficult to integrate with the specific, precise, and detailed information developed through photo-interpretation, field checks, and shellfish surveys.

- Despite the effectiveness of photo-interpretation, many features, both geological and biological, require on-site field checks to ensure proper identification, and in certain cases, areal extent of the feature.

- Shoreside and boat surveys are effective methods of conducting on-site field checks, however, in complex areas and where shoreside or boat access is limited, the use of an airboat or helicopter may prove both efficient and cost-effective despite high initial expense.

- Video recordings of surveys, particularly low-level, low-velocity aerial surveys, provide a lasting record of the survey and allow repeated, detailed review of the surveyed area, ultimately increasing the level of detail of correction while reducing overall cost.

Recommendations

- When printing maps for annotation and field checks, an overlap of 2 or 3 inches between adjoining maps should prove sufficient to ensure full areal coverage. Multiple representations of a specific area should be avoided to prevent confusion and duplication of effort.

- Back-to-back map lamination reduces both cost and the number of individual maps one has to deal with. However, to reduce the number of maps required in the field and allow several surveyors to work simultaneously in the field, maps series for the same study area should be backed together, although adjoining maps should be kept separate to allow side-by-side placement.

- For complex areas, it would be preferable to use at least two separate copies of the maps for such areas, one for photo-interpretation corrections and the other for field check notations.

- If anecdotal and quantitative information are to be integrated, the methodology for accomplishing this should be understood early in the process. The interview structure should be designed around the way the results are to be used.

- Municipal documents dealing with shellfish resources are often difficult to obtain and should therefore be requested early in the process.

- Although astronomically low tides allow observations that are difficult or impossible at other tides, astronomical tides often occur either during the night or early morning hours, or at dusk or early evening hours. The oblique angle of light at these hours usually does not penetrate deep enough to allow a clear view of the bottom and often casts shadows. Furthermore, astronomical tides are often accompanied by bad weather.

- All notations made on the laminated maps during photo-interpretation, interviews, and on-site field checks should be made in a task specific color to allow distinction between task notations. All field check notations should include the date, time, and somewhere near the area checked, the time and height of tide for the date.

- When conducting shoreside field checks it may be advisable to provide homeowners and/or landowners prior notification that a survey crew will be working in their area through newspaper notices or direct mailing. Cards giving general project information and a phone number of a project contact might be made up to be left on private property as a courtesy during shoreside fieldwork.

- A photographic key that includes all geological and biological features, along with the individual technical description, alpha-numeric code, and mapping color code, would be valuable to those unfamiliar with specific geological and biological features.

- To ensure proper identification and representation of features, consideration might be given to selecting strongly contrasting colors for similar features, particularly where such features occur adjacent to each other in nature.

References

Anonymous, 1977. Maine Coastal Inventory, Fish and Wildlife Atlas Series 1 and 2, Maine State Planning Office, Augusta, ME.

Anonymous, 1976. Bivalve Shellfish Distribution of Coastal Maine, U.S. Environmental Protection Agency and Maine Department of Marine Resources, Atlas.

Fefer, S. I. and P.A. Schettig, 1980. An Ecological Characterization of Coastal Maine (North and East of Cape Elizabeth), Department of Interior, U.S. Fish and Wildlife Service, Vol. 6, Atlas.

Heinig, C.S. and B.P. Tarbox, 1984. A Range and Distribution Study of the Natural European Oyster, *Ostrea edulis*, Population in Casco Bay, Maine, 82 pp.

Heinig, C.S., P.J. Moore, D.W. Newberg, and L.R. Moore, 1995. Economic Analysis of the Soft-shell Clam, *Mya arenaria*, Industry in Casco Bay. Report to the Casco Bay Estuary Project, 93 pp.

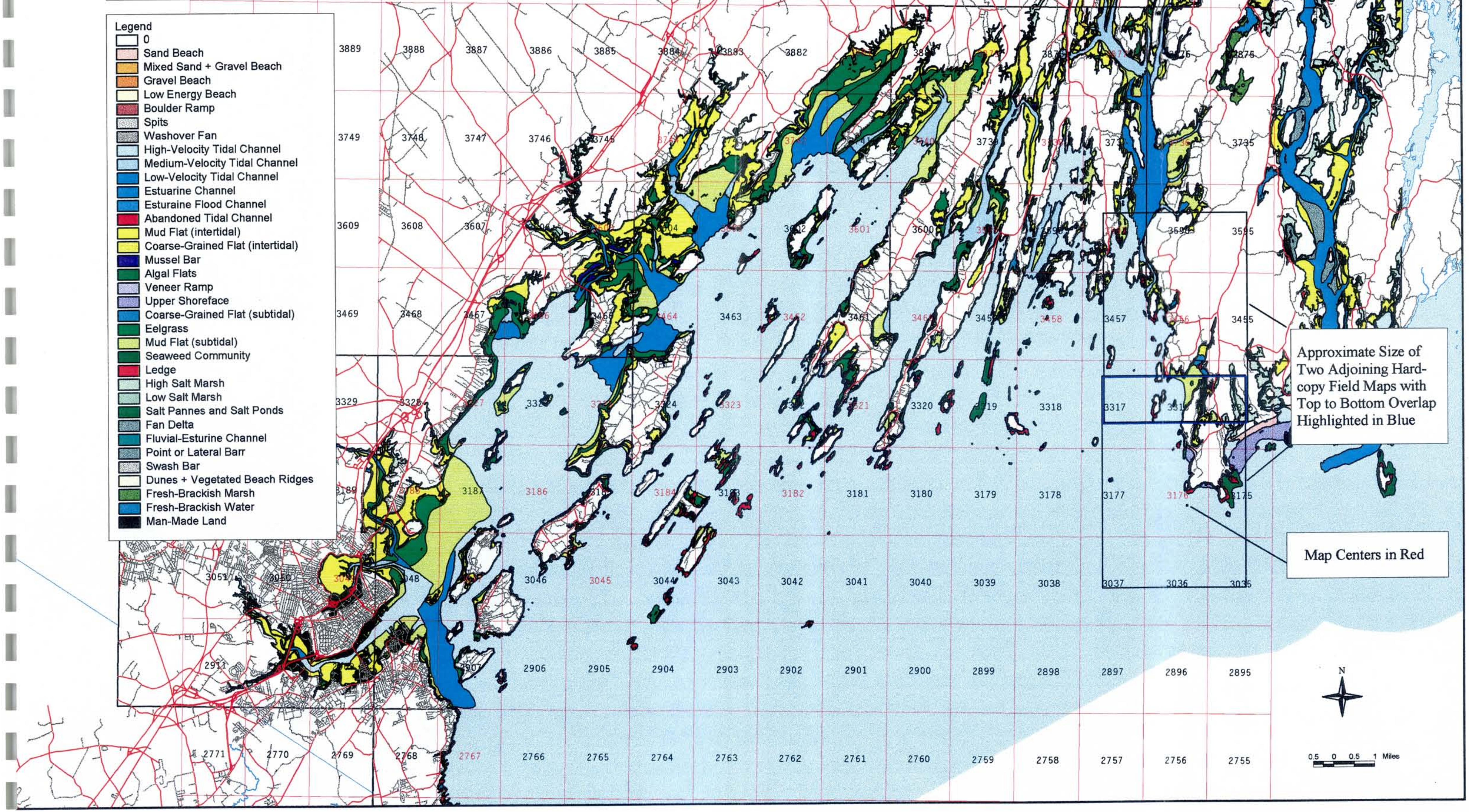
Maritec, 1978. An Inventory of the Blue Mussel (*Mytilus edulis*) Stocks from the Damariscotta River Esturay to Jonesport, Maine, 111 pp.

Appendix

GIS Index Map - Casco Bay
Geological and Biological Features Color Legend
Aerial Photo Index Maps
Interview List
Casco Bay Clam Survey Interview Format

GIS Index Map - Casco Bay
and
Map Lamination Index

Coastal Marine Geologic Environments of Casco Bay
Map Showing Reference and Tic Grid



2487	3176		**3458**	3597
2767	3182		**3460**	
2908	3324		**3462**	3742
2910	4017		**3464**	3744
3045	3049		**3466**	3601
3047	3738		**3596**	3319
3049	3045		**3597**	3458
3176	2487		**3598**	3185
3182	2767		**3599**	3188
3184	3736		**3601**	3466
3185	3598		**3603**	
3186	3877		**3605**	
3188	3599		**3736**	3184
3316			**3738**	3047
3319	3596		**3740**	3325
3321	3456		**3742**	3462
3323	3879		**3744**	3464
3324	2908		**3877**	3186
3325	3740		**3879**	3323
3327	3881		**3881**	3327
3456	3321		**4017**	2910

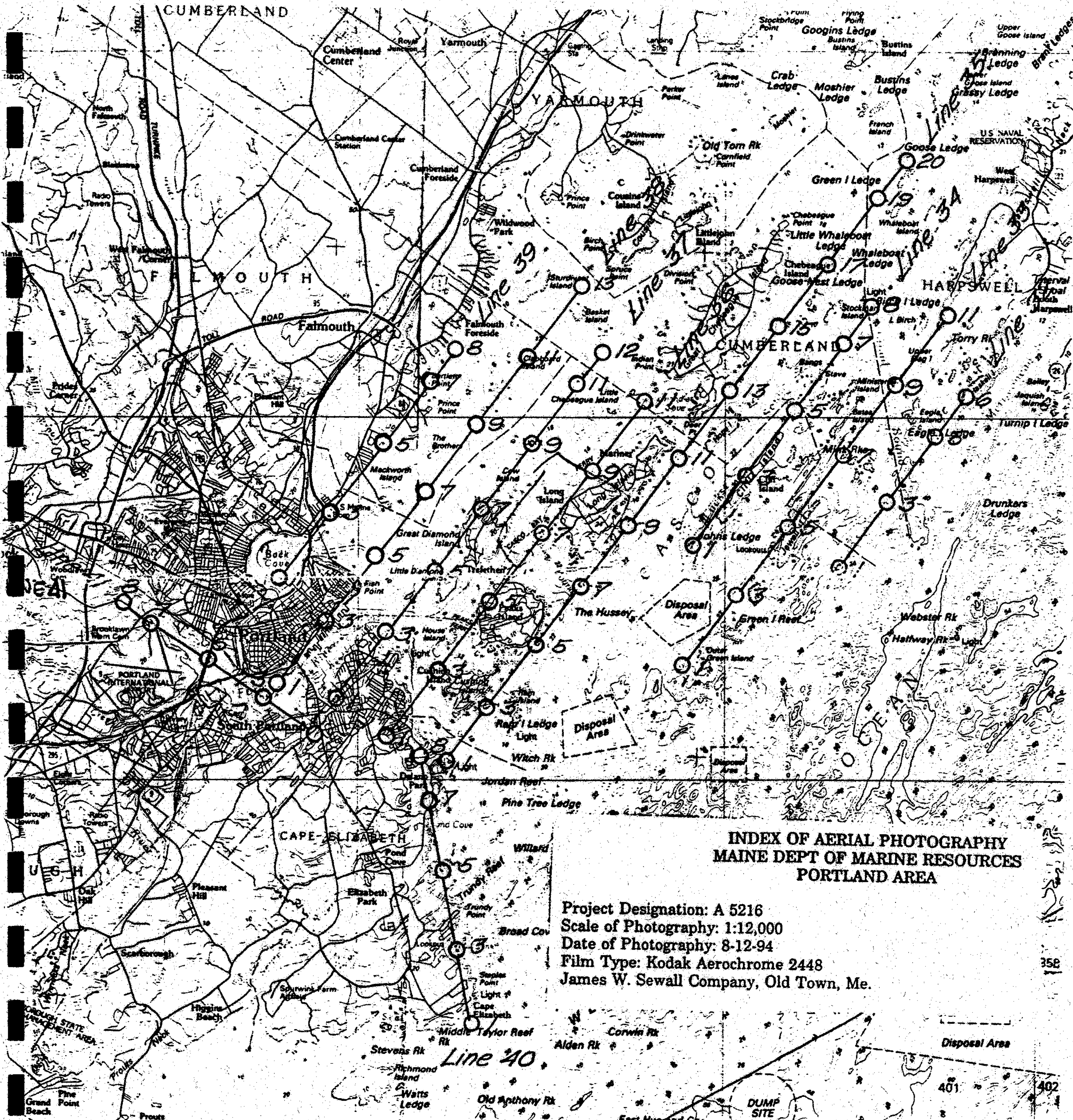
Geological and Biological Features Color Legend

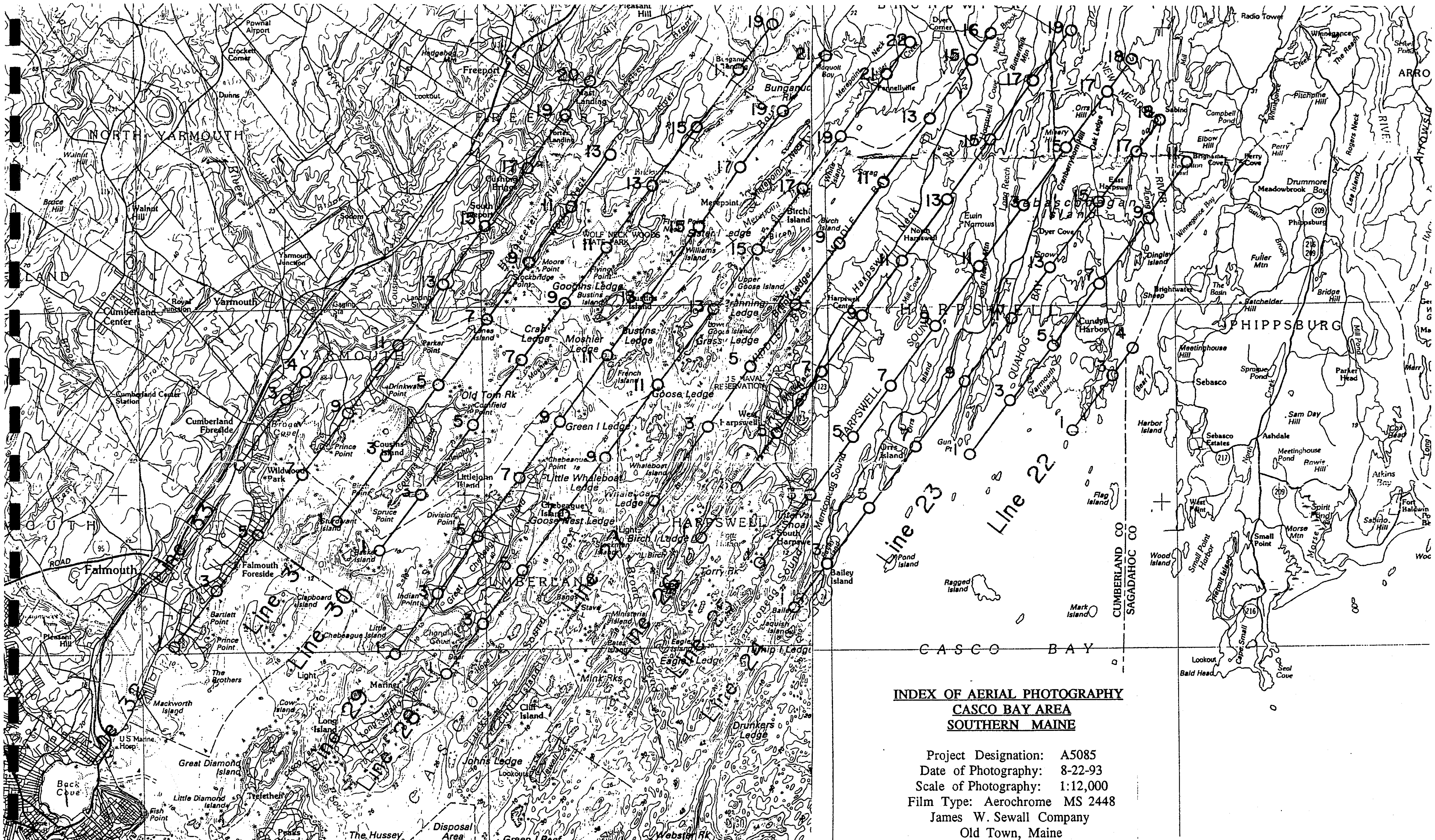
Unit.shp

- 0
- Sand Beach
- Mixed Sand + Gravel Beach
- Gravel Beach
- Low Energy Beach
- Boulder Ramp
- Spits
- Washover Fan
- High-Velocity Tidal Channel
- Medium-Velocity Tidal Channel
- Low-Velocity Tidal Channel
- Estuarine Channel
- Esturaine Flood Channel
- Abandoned Tidal Channel
- Mud Flat (intertidal)
- Coarse-Grained Flat (intertidal)
- Mussel Bar
- Algal Flats
- Veneer Ramp
- Upper Shoreface
- Coarse-Grained Flat (subtidal)
- Eelgrass
- Mud Flat (subtidal)
- Seaweed Community
- Ledge
- High Salt Marsh
- Low Salt Marsh
- Salt Pannes and Salt Ponds
- Fan Delta
- Fluvial-Esturine Channel
- Point or Lateral Barr
- Swash Bar
- Dunes + Vegetated Beach Ridges
- Fresh-Brackish Marsh
- Fresh-Brackish Water
- Man-Made Land

Aerial Photo Index Maps

NOTE:
Lines 30S + N + 31 = New Meadows




INDEX OF AERIAL PHOTOGRAPHY
CASCO BAY AREA
SOUTHERN MAINE
Project Designation: A5085
Date of Photography: 8-22-93
Scale of Photography: 1:12,000
Film Type: Aerochrome MS 2448
James W. Sewall Company
Old Town, Maine
Line 22
Line 23
Line 30
CASCO BAY
CUMBERLAND CO
SAGADAHOC CO
NORTH YARMOUTH
YARMOUTH
FREEPORT
HARPSWELL
PHIPPSBURG
Falmouth
Cumberland Center
Freeport
Yarmouth
Back Cove
Bailey Island

30-11
29-12

Interview List

Dana Wallace, Brunswick
Alan Houston, Brunswick
Peter Angis, Scarborough
Clinton A. "Ken" Goodenow, Freeport
Bradford Varney, Freeport
Edgar "Ted" Curtis, Yarmouth
Richard Lemont, Phippsburg
Gene "Tyke" Graffam, II, Harpswell
Russell Coffin, Harpswell
Jon Hentz, Georgetown, West Bath and Phippsburg Warden
Donald Card, MDMR
Mick McGivaren, Freeport
Thomas Bennett, Freeport
Joseph Payne, Westbrook
Kim Payne, Westbrook

Casco Bay Clam Survey Interview Format

1. Name & Contact Information

____

____

____

2. What length of time have you been involved with the shellfish industry?______________

☐ Commercial Digger ☐ Shellfish Dealer
☐ Shellfish Warden ☐ Industry Consultant
☐ Shellfish Commission Member

Level of experience:		Rating s:			
	A= active,		0= no resource	O.P.=	overall productivity
	P= passive		1= poor	Qual=	quality of shellfish
	1= little		2=fair	Y/U=	yield per unit effort
	2= moderate amount		3= good	S/U=	sustainability per unit effort
	3= large amount		4= very good	EASE=	ease of harvest
	5= excellent			BOT=	type of bottom

3. What geographic area of Casco Bay have you worked in?

Area 1:______________________________ Size:____________________

SPECIES	LEVEL	O.P.	QUAL	Y/U	S/U	EASE	BOT			
clam	A/2									
oyster	P/1									
razor	etc.									

Area 2:______________________________ Size:____________________

SPECIES	LEVEL	O.P.	QUAL	Y/U	S/U	EASE	BOT			
cockle	A/2									
mussel	P/1									
	etc.									

Area 3:______________________________ Size:____________________

SPECIES	LEVEL	O.P.	QUAL	Y/U	S/U	EASE	BOT			
clam	A/2									
mussel	P/1									
razor	etc.									
quahog										

Area 4:______________________________Size:____________________

SPECIES	LEVEL	O.P.	QUAL	Y/U	S/U	EASE	BOT			
clam	A/2									
mussel	P/1									
razor	etc.									

5. Does the map properly depict the flat in question?

____

____

6. What are the boundary of the harvestable area of the flat?

____

____

7. What are the problems associated with this area (historic, recent?)

____

____

8. Are there harvesting conflicts associated with this area? If so, what are they?

____

____

9. Include Urchins???