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Using a Geographic Information System to Evaluate the Effects of Shellfish Closures on Shellfish Leases, Aquaculture and Habitat Availability

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Abstract

1992

Legault, J.A., 1990. Using a Geographic Information System to Evaluate the Effects of Shellfish Closure Zones on Shellfish Leases, Aquaculture and Habitat Availability. Can. Tech. Rep. Fish. Aquat. Sci. 1882E: iv+10

A Geographic Information System is used to evaluate the extent to which the closure of shellfish areas due to bacterial contamination effects the shellfish industry in Eastern Prince Edward Island. The GIS system is used to detrmine the areas of shellfish growing leases, shellfish harvesting zones and contaminated closure zones. A comparison is made between the areas and an estimated value is determined. Due to lack of precise information the estimated total market value of the shellfish harvested in the area examined has a wide range between $7.2 and $0.22 million. The shellfish production from leases within closure zones has an approximate market value of $52,000. Further uses of the GIS are briefly explored, in particular, its use as a planning tool to avoid pollution sources and to assist in priorizing research surveys. The human and Departmental infrastructure for data collection and processing must be established and supported in order to operate an effective program using GIS technology .

Résumé

Legault, J.A. 1990. Évaluation des effets des interdictions de pêcher les mollusques sur les parcs coquilliers, l'aquiculture et l'habitat, au moyen d'un système d'information géographique. Rapp. tech. can. sci. halieu. aquat. 1882F: iv+10

Un système d'information géographique sert à évaluer la mesure dans laquelle l'interdiction de pêcher dans les secteurs coquilliers à cause de la contamination terrestre, a des effets sur l'industrie de la pêche des mollusques dans l'Est de l'Île-du-Prince-Édouard. Le SIG sert à délimiter les parcs coquilliers loués à bail, les secteurs de pêche de mollusques et les zones interdites en cas de contamination. On établit une comparaison des secteurs et on en détermine la valeur approximative. À cause du manque d'information précise, l'échelle de valeur est très étendue, soit entre 7,2 et 0,22 millions de dollars. La valeur approximative au marché de la production de mollusques dans les parcs coquilliers à bail, dans les zones interdites, est de 52000 dollars. On étudie brièvement d'autres possibilités d'utilisation du SIG, en particulier en tant qu'outil de planification permettant d'éviter les sources de pollution et d'aider à établir les priorités des levés de recherche. Il faut mettre en place les ressources humaines et l'infrastructure ministérielle nécessaires à la collecte et au traitement des données et en assurer le soutien pour pouvoir appliquer efficacement un programme ayant recours à la technologie du SIG.

PREFACE

Throughout Atlantic Canada municipal sewage is widely disposed of by direct discharge into the coastal zone without treatment so that the waters become contaminated to varying degrees with bacteria, viruses and toxic chemicals. Industrial discharges and agricultural runoff contribute to the problem. Molluscan shellfish—primarily oysters, soft-shell clams and mussels—live and grow by filtering food from the shallow intertidal waters in which they live. They are, therefore, prone to contamination when these waters become polluted. Based upon sanitary conditions and bacteriological water quality, specific growing areas sometimes have to be closed to protect human health. These closures affect both aquaculture operations and "wild" shellfish harvesting. Such action can have a ripple effect on the economy of a region, resulting in the loss of thousands of dollars to the fishery and contributing to unemployment, decreased tourism, and higher prices to consumers. The economic and social costs arising from lost shellfish harvesting opportunities in the Atlantic Zone pollution are not accurately known.

In 1988, the Coordinating Committee for Atlantic Habitat Management (CCAHM) developed a project through its Marine Atlantic Standing Subcommittee on Habitat (MASSH) to address this issue. This project, which was to be undertaken largely by contract and to cover the entire Atlantic zone, was planned to be completed in three stages as follows:

Stage 1 — Assemble, map and quantify data on shellfish stocks and harvesting sites within Atlantic Canada; determine the areal extent of shellfish closures; and assemble and map information on sewage pollution sources.

Stage 2 — Attribute economic and social costs arising from lost shellfish harvesting opportunities due to sewage, etc. pollution.

Stage 3 — Determine realistic alternatives to current sewage disposal and management practices that will ultimately lead to the lifting of closures.

In any event, sufficient funds were not forthcoming to fund this work. MASSH decided, therefore, to initially restrict the geographic scope of the study to part of the Atlantic zone and to undertake most of the work in-house. This first phase would, in effect, be a pilot phase in the expectation that the results would demonstrate the feasibility of the approach and hence facilitate the completion of the entire project as originally envisaged.

The first phase, which is the subject of this report, was centered in DFO's Gulf Region utilizing that Region's newly installed Geographic Information System (GIS). It is the conclusion of MASSH that the methodology of utilizing a Geographic Information System to address the shellfish closures issue has been successfully demonstrated through this project. This report includes recommendations for the adoption of the methodology by regions and others, e.g. the provinces. MASSH has facilitated the development of a technique to address the shellfish harvesting closures issue but it does not now see itself as the body to apply the technique throughout the Atlantic zone. This represents a change from the original intention, which envisaged that MASSH would actually undertake the project. It has become apparent as the initiative has progressed that MASSH is not structured, or funded, to "manage" a project such as this that involves extensive data collection, mapping, etc. What MASSH can do, as has been demonstrated in this instance, is to act as a catalyst in devising a technique or approach to address a problem. MASSH will still maintain an overall outlook on this issue, specifically with reference to the original objective of attributing economic and social costs arising from lost shellfish harvesting opportunities due to sewage and other pollution.

H.B. Nicholls, Chair
Marine Atlantic Standing Subcommittee on Habitat

Introduction

Every year, the Department of Fisheries and Oceans (DFO) closes shellfish beds throughout the Atlantic Provinces that are contaminated by bacteria, specifically fecal coliform. This is done after consultation with Environment Canada following USFDA and Canadian DFO and DOE guidelines (see footnote below). Environment Canada conducts annual sampling programs to determine the level of bacterial contamination. When the results are compiled, map coordinates are determined and areas of influence are closed to public and private shellfish harvesters. In some cases, conditional closures are designated restricting shellfish harvests during certain times of the year.

Often, these closure zones have an impact on fishermen who lease shellfish beds to raise shellfish for commercial markets. When their leases are included in a closure zone, they must relocate their animals to a clean area to depurate. This involves considerable effort on the part of the fisherman and increases the cost of his product. Further, the leases located in or near closure zones may also be suspect and the sales of their product may be jeopardized.

The possible causes of this contamination result from a combination of poor land and water use management, poor municipal planning, disfunctional sewerage systems and outdated environmental regulations.

DFO's Coordinating Committee for Atlantic Habitat Management (CCAHM) through its Marine Atlantic Standing Sub-Committee on Habitat (MASSH) funded a pilot study to quantify the shellfish habitat affected and the shellfish market lost or jeopardized as a result of designated closures. DFO's Gulf Region Geographic Information System (GIS) Project undertook this study to evaluate the shellfish leases, public beds and approved areas on the eastern coast of Prince Edward island. An additional part of this study was to identify potential point-sources of pollution to determine their relationship to the closure zones. The purpose of this study was to determine the ability of a computerized system to analyze data as data becomes available and required by the managers and to ask questions about the areas of concern and to use the computer to visually represent the data for decision makers.

The Pilot Project

The Gulf Region's GIS Project operates the CARIS (Computer Aided Resource Information System) developed in Fredericton, New Brunswick by Universal System Ltd. The system runs on a MicroVax II with only 300 Mbytes of disk space using the VMS operating system. The relational data base that CARIS uses is the INGRES data base. The size limitations of the hardware severely limited the capability of the system to fully handle all the information and maps already available as well as manipulating any new data that had to be entered.

The guidelines followed are: The National Shellfish Sanitation Program Manual of Operations part 1, 1989 revision USFDA and the Canadian Shellfish Program Manual of Operations Chap. 2 (DFO and DOE)

Since this was a joint project in cooperation of Environment Canada, the data on approved shellfish zones, closure areas, and data on pollution sources was also input into a related data base. $9,000 was provided by MASSH to support the acquisition of data. Environment Canada provided data in digital and hardcopy form and the Gulf Region provided the digital maps, shellfish lease data and the expertise to put the information into the GIS and conduct the inquiry. However, the funding was insufficient to permit mapping and analysis of shellfish closures in the entire Atlantic zone and was therefore limited to the Eastern Coast of Prince Edward Island and focused on the Cardigan, Brudenell and Montague Rivers.

During the domoic acid crisis of 1987 (Addison and Stewart, 1989), all the shellfish leases on the eastern coast of Prince Edward Island and northeastern parts of New Brunswick were digitized into a GIS format. Further, information on lease owners in New Brunswick was also entered into a data base. Coastline, roads, and county division base maps, as well as the shellfish lease maps, were reformatted into CARIS and the textual data for Prince Edward Island leases was input into the INGRES data base system.

The resulting product of the GIS exercise was to be able to produce "on-demand" maps of the coastline and near shore, shellfish closure zones, shellfish approved zones, shellfish leases, land-based pollution sources (specifically, wastewater outfalls) and to further produce corresponding tables of data (e.g. on leases, the economic value of their production, and the impact of closure zones.

It is very important to recognize that in reality the approved zones for shellfish harvesting are not all suitable habitat for shellfish. Therefore the information extrapolated below is an over-estimate of production potential for the approved areas. The values presented are not true production estimates or economic levels. The data limitations do not permit this kind of detail. The purpose of this study was to show the capabilities and limitations of a GIS and the possibilities of using such a tool for the evaluation of habitat impacts.

Results

The maps and reports produced by the GIS all met the above criteria, with one qualifier. The system is not presently as user friendly as would be required if this were to be a routinely used tool. The faults are not with the technology but rather reflect hardware limitations and DFO's inexperience with GIS. Although a menu driven interface was developed to demonstrate the the system's ease of use when properly programmed, there was insufficient time to address all the possible data combinations and map queries possible. Therefore, this report restricts its scope to the feasibility of the GIS tool in the evaluation of the closures and their effects on values to the fishery and the market.

Fig. 1 indicates base map features such as the coastline. Base maps are available from many sources and at a variety of scales. Some will also include bathymetry, watersheds and topography, but at an added cost. In this case all that was required was the coastline, and some roads. Other features

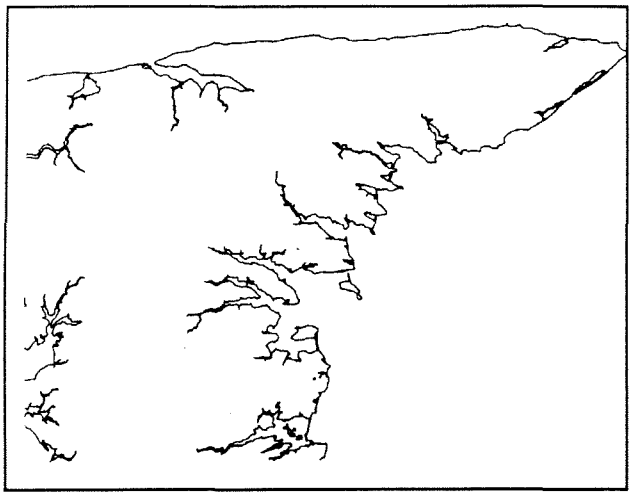

Fig. 1. The coastline base map of the east coast of Prince Edward Island.

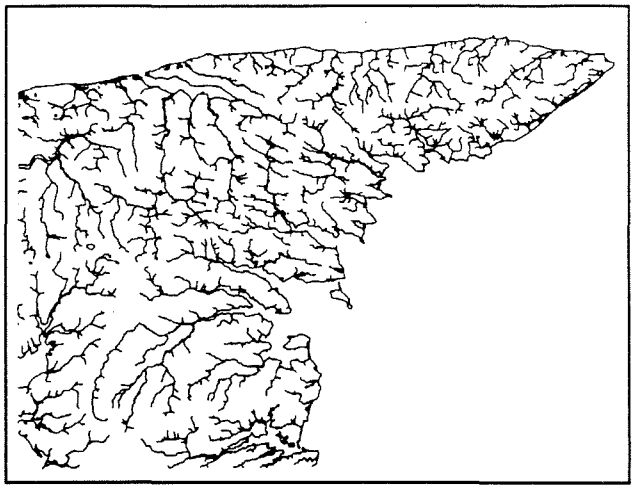

Fig. 2. The river systems data layer of eastern Prince Edward Island as generated by the G.I.S.

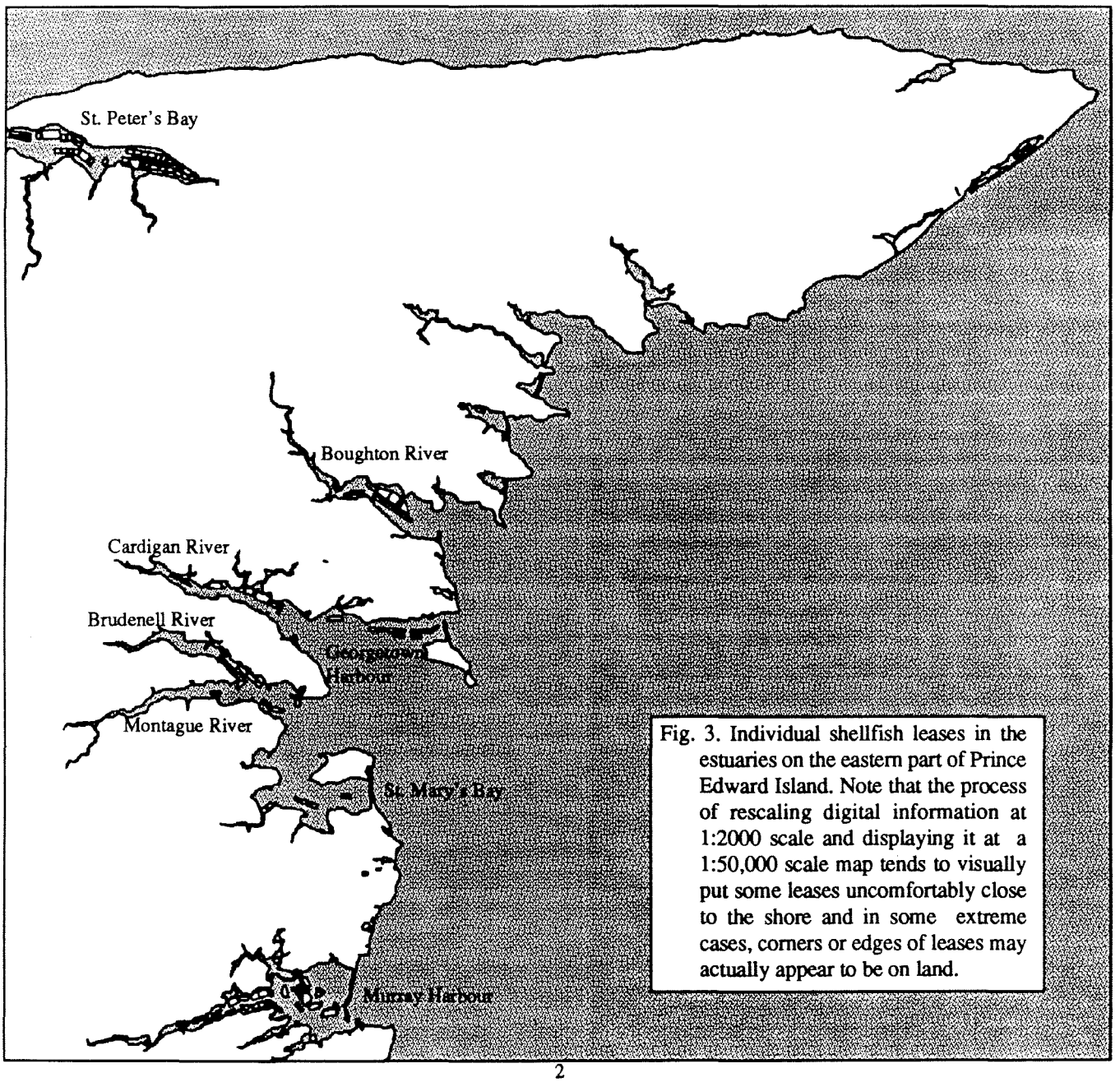

Fig. 3. Individual shellfish leases in the estuaries on the eastern part of Prince Edward Island. Note that the process of rescaling digital information at 1:2000 scale and displaying it at a 1:50,000 scale map tends to visually put some leases uncomfortably close to the shore and in some extreme cases, corners or edges of leases may actually appear to be on land.

were turned off. Should other features be desired, it is simple to turn the feature on and displaying the resulting map, as in Fig.2., which shows the individual river systems in the eastern part of Prince Edward Island.

Maps of the individual leases are shown in Fig. 3. This is an integrated compilation of individual 1:2000 scale maps taken from survey sketches with benchmarks, angles and distances from the benchmarks. These were digitized directly using the data from the drawings. The coordinates were then calculated and the individual lease maps were overlain onto a 1:50,000 scale map. The resulting map shows all the leases (data from Fisheries and Habitat Management Branch, DFO - 1987) on the eastern part of Prince Edward Island.

Another method of entering and displaying data is to enter only the latitude/longitude or Universal Transverse Mercator (UTM) coordinates. Through a small batch process the computer can draw lines between given sets of coordinates and, in this case, delineate the approved and closed shellfish zones. The digitized coastline associated with coordinates or which cross the line generated by joining the pairs of coordinates is cut and replicated to make an entire closed polygon for the "classified zone". Through further processing, shading or patterns can be added to the areas to make them stand out better. Fig. 4. demonstrates this by displaying only the classified shellfish harvesting areas.

Every year, Environment Canada produces such maps to indicate the opened, conditional and closed zones for shellfish harvesting in the Maritimes. The maps generated for this purpose are accurately hand drawn and shaded and printed for publication. The use of a GIS could greatly facilitate the drawing of these maps since all the data could be entered as coordinates only and revised annually by simply asking the system to redraw the maps and closure zones from existing and new data. Further, as new data on closure zones are collected, updates could be generated on request rather than once-a-year and the cost of sending revised copies of a binder of maps could be reduced. Updates simply could be added to existing books and binders and the cost spread out over the year.

To further assist a resource manager, the GIS has the capability of zooming-in to an area of interest to show more detail and facilitate the selection of features for data enquiries. Figs. 5 and 6 show such a manipulation. Fig. 5 is a close-up display of the Cardigan, Brudenell, Montague River estuaries. Imaginary lines have been generated to delineate the individual river mouths or watersheds. These lines permit the definition of polygons and calculation of the area of individual river systems from headwater to ocean. Four areas were delineated specifically for this project due to restrictions in the data base size and the hardware used: the Cardigan River Estuary, the Brudenell & Montague River Estuary and the Georgetown Harbour area. These areas are all within the approved shellfish harvesting zones.

Fig. 6. demonstrates how the closure zones can be drawn quickly by again inputting only the shoreline coordinates as either latitude/longitude or as UTM coordinates. Environment Canada could quickly generate the maps and reports they annually produce using this method to draw the closed, conditional and approved shellfish harvesting zones. Further, the Department of Fisheries & Oceans could analyze the trends and probable impacts upon the shellfish industry as a result of the closures using the GIS.

Overlaying the lease outlines onto the base map and the closure zones (Fig. 6) easily allows an observer to determine the extent of impact that a particular closure zone could have on the aquaculture operations in an area.

Using these maps, the GIS can also calculate the areas (ha) of each zone, or total all the areas in a Region. Tables can be generated to determine the differences between the two zone types. The following series of tables were generated through batch jobs on the GIS and output to an ascii file and reformatted for this report.

Data about the leases can be pulled out of related data bases such as ownership, species cultures and shellfish production levels (when available). It should be noted that the mapped information for the leases is from 1987 maps, yet the data for the leases are 1988 data. In some cases, there

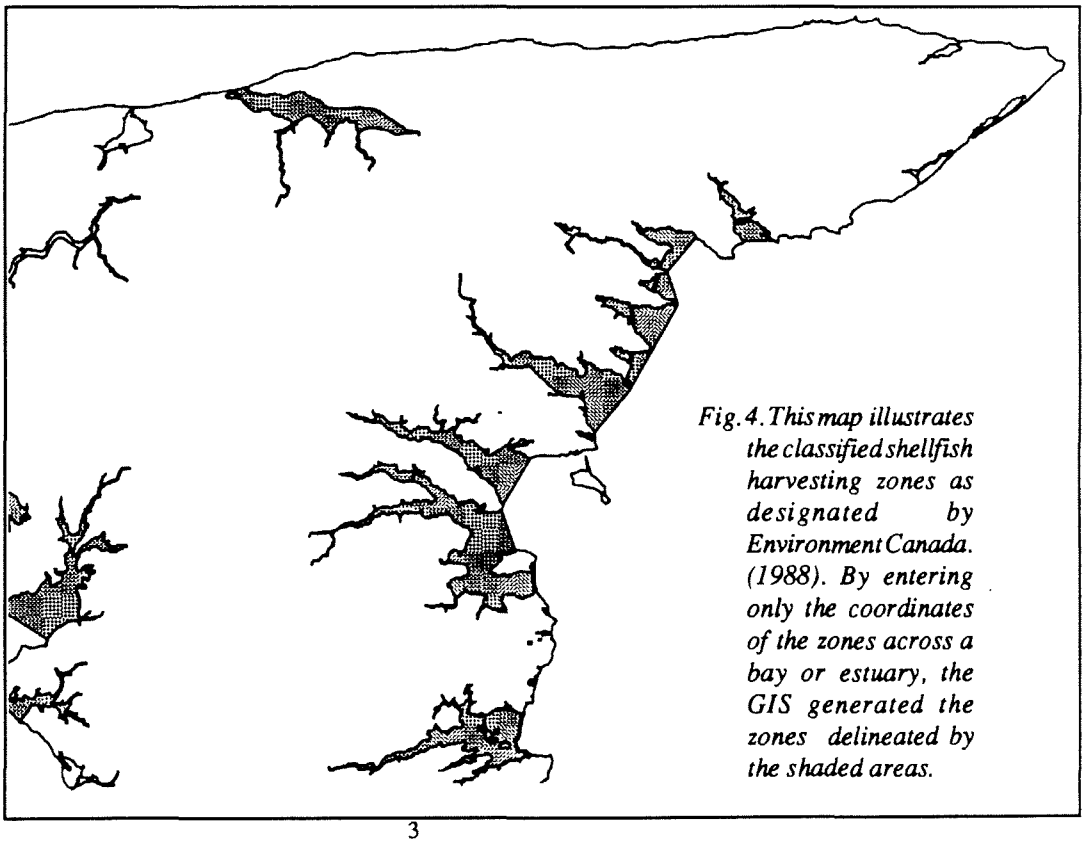

Fig. 4. This map illustrates the classified shellfish harvesting zones as designated by Environment Canada. (1988). By entering only the coordinates of the zones across a bay or estuary, the GIS generated the zones delineated by the shaded areas.

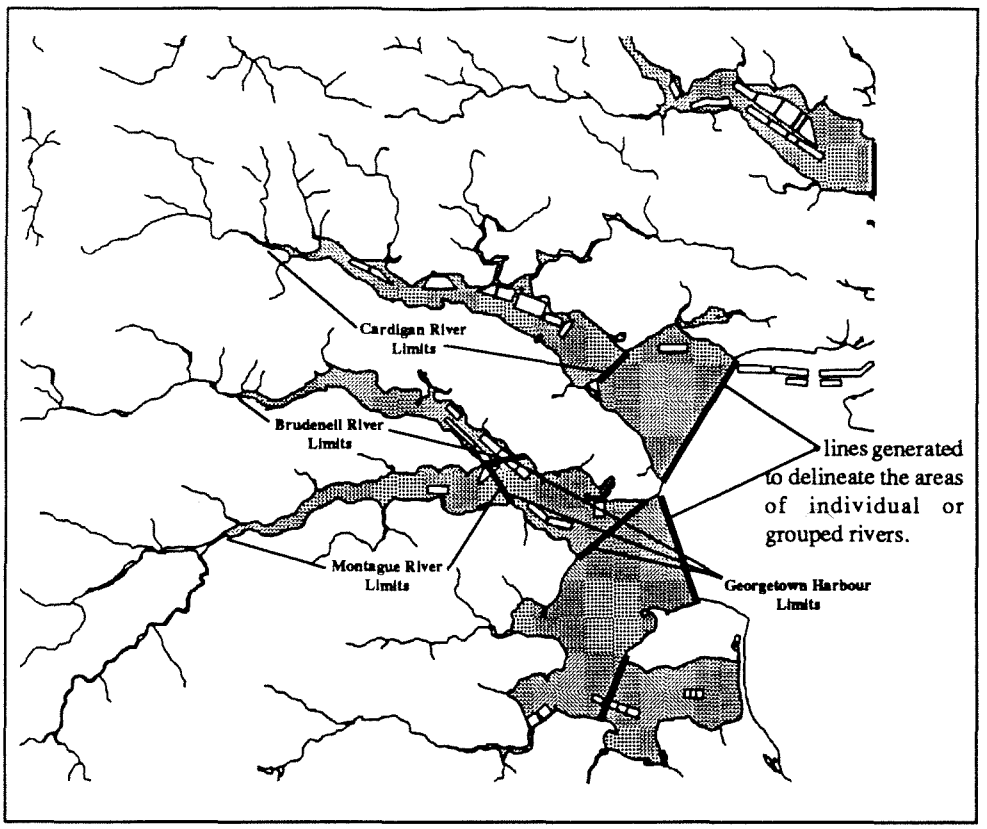

Fig. 5. Close-up of Cardigan, Brudenell and Montague River estuaries showing individual leases and the polygons defining the mouths of individual rivers and grouped rivers.

For the purposes of this project four main areas were delineated:

1. The Cardigan River Estuary
2. The Brudenell River Estuary
3. The Montague River Estuary
4. The Georgetown Harbour Area

Some of the lease areas actually comprise more than one individual lease, owned by the same individual but physically separate. The lines do not appear on these maps but the data is recorded for each sub-lease.

are lease maps without production data (the owner is not working his lease) and there are production data in the data base without mapped leases (from new leases being issued). Only those leases which are digitized and for which data were provided are represented to demonstrate the selection capabilities of the GIS. A list of leases for which one or the other pieces of data are missing could have been generated through a similar batch process.

Tables 1 and 2 are outputs that list the leases found in a designated area. The lease ID# is the Department's identifier assigned when the lease was granted. The area of the lease is calculated by the system when the lease is initially digitized and stored as an attribute of the polygon.

The lease production data, as collected by the Department, were not collected in a standard fashion over the years and often the lease production rates were expressed as boxes, barrels, lines, pounds and, recently, in kilograms. There is also no indication of the area a grower was using in his lease ... whether he was using, for example, half or a third of his lease area in any given year. Thus any extrapolation for the entire area based

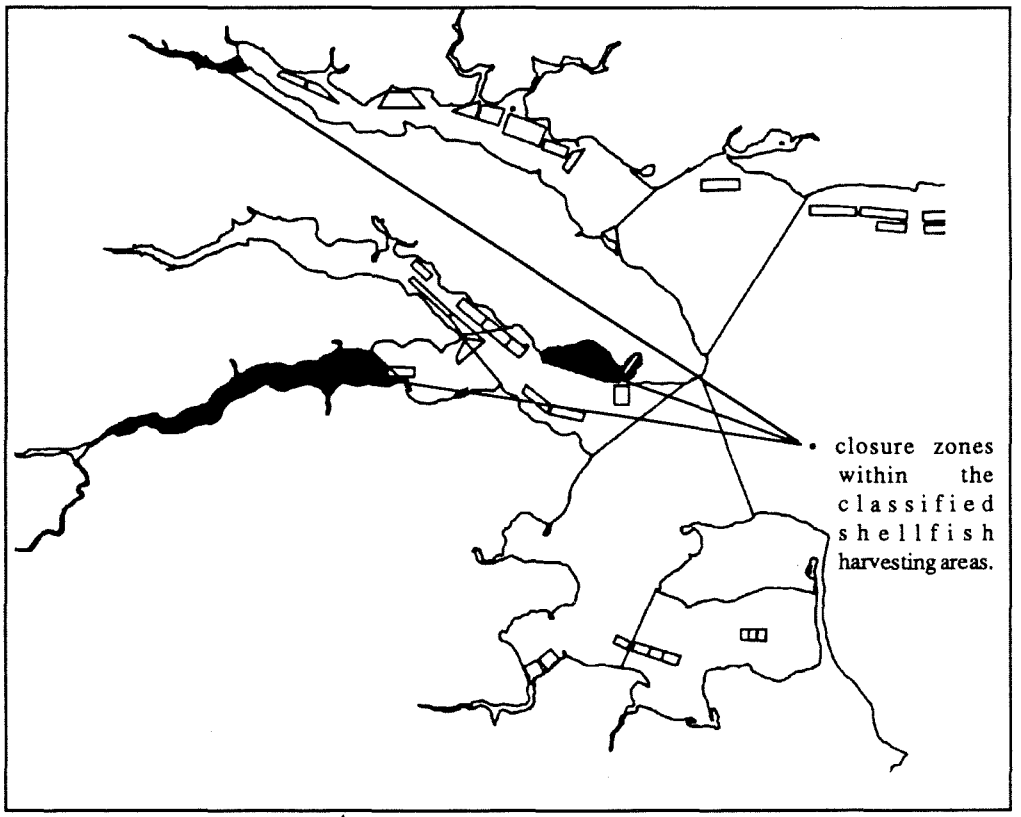

Fig. 6. Close up of the Cardigan, Brudenell and Montague estuaries indicating the closure lines delineated by Environment Canada (1988). These areas are classified as closed on the basis of E. coli contamination and proximity to harbours and wharves.

Table 1 - Estimated Production of Shellfish Leases in the Cardigan River

Lease I.D.	Area(ha)	Estimated Production (MT) High	Medium	Low
!10010	7.64	194.13	53.20	5.89
F023C	0.32	8.20	2.25	0.25
M-0117A	7.93	201.32	55.16	6.10
M-0117B	8.66	220.01	60.29	6.67
M-0117C	21.63	549.43	150.55	16.66
M-0121A	9.11	231.32	63.38	7.01
M-0121B	14.35	364.57	99.90	11.05
M-0163	31.56	801.73	219.69	24.30
M-0225	10.05	255.35	69.97	7.74
M-0258	15.73	399.59	109.49	12.11
Grand Totals:				
N:	10			
Sum:	126.99	3225.65	883.88	97.79
Avg:	12.70			

on the reported harvest of the aquaculture operator probably results in an underestimate of the production. It is also very tricky to provide an actual dollar value to the fishery lost to a closure zone. Sales are not registered per lease as such by the Department and market values vary during the season depending on quality of product, season and demand. Thus, rather than expressing the market value of the fishery lost as a result of the closure, it would be more realistic to discuss the areas (ie. the leases as % of the total closure zone) affected.

For the purposes of this report, published producion rates of wild oyster beds in the Dunk River (Sephton & Bryan, 1989) were used to roughly calculate the lease production in the Cardigan and Brudenell and Montague Rivers. It must be emphasized that this **is not** representative of the true species production rates in the areas under review. The values are being used strictly as an exercise to demonstrate the capabilities of a GIS should actual data be available. In the study, three production rates were qualified - **High** (25.4 Metric Tons per hectare); **Medium** (6.96 MT/ha) and **Low** (0.77 MT/ha). Tables 1 and 2 are also examples of summaries of the individual lease annual productions in selected rivers (in this case the Cardigan, Brudenell & Montague Rivers) using the above biomass production rate values but do not give an indication of the actual dollar value of the shellfish.

Table 2 - Estimated Production of Shellfish Leases in the Brudenell & Montague Rivers

Lease I.D.	Area(ha)	Estimated Production (MT) High	Medium	Low
!10001	11.36	288.44	79.04	8.74
!10002	0.31	7.87	2.16	0.24
4949	1.32	33.60	9.21	1.02
5974	1.84	46.76	12.81	1.42
M-0048	12.14	308.25	84.47	9.34
M-0052	11.75	298.37	81.76	9.05
M-0080	11.88	301.85	82.71	9.15
M-0100	11.15	283.34	77.64	8.59
M-0274A	13.36	339.29	92.97	10.29
M-0274B	7.20	183.01	50.15	5.55
M-0278	14.58	370.38	101.49	11.23
M-0285	8.73	221.79	60.77	6.72
M-0287	4.63	117.55	32.21	3.56
M-0295	10.30	261.49	71.65	7.93
M-0304	12.10	307.37	84.22	9.32
Grand Totals:				
N:	15			
Sum:	132.65	3369.39	923.26	102.14
Avg:	8.84			

Table 3 - Estimated Potential Production of Classified Growing Areas in the Cardigan River

Shellfish Growing Area Size (ha)	Estimated Production(MT) High 25.4MT/ha	Medium 6.96 MT/ha	Low .77 MT/ha
CARDIGAN RIVER			
845.7	21479.9	5885.8	651.2
Grand Totals:			
Sum:			
845.7	21479.9	5885.8	651.2

In the Cardigan River estuary, 10 leases represent a total area of 126.99 hectares with a potential production range from 97.8 to 3225.65 Metric Tons per year. The results for the 15 Brudenell/Montague estuary leases with a combined area of 132.65 hectares range from 102.1 to 3369 MT/y.

It is assumed that the value for the highest production rates is likely applicable to the shellfish leases since these are areas that are artificially enhanced and "cared for" as opposed to wild stocks, even though it is conceivable that lower rates are possible. Much of these data-gap problems can be overcome through better data collection and reporting by the fishermen. The scope of this work did not permit this extensive kind of data proofing.

Tables 3 and 4 represent the potential production of the classified growing zones, as defined by Environment Canada (1988). The areas were then selected as part of the

Table 4 - Estimated Potential Production of Classified Growing Areas in the Brudenell, Montague Rivers and Georgetown Harbour

Shellfish Growing Area Size (ha)	Estimated Production(MT) High 25.4MT/ha	Medium 6.96 MT/ha	Low .77 MT/ha
BRUDENELL RIVER			
403.5	10247.9	2808.1	310.7
GEORGETOWN HARBOUR*			
519.9	13204.6	3618.3	400.3
MONTAGUE RIVER			
495.6	12588.6	3449.5	381.6
Grand Totals:			
Sum:			
1418.9	36041.1	9875.8	1092.6

* See figure 5 for the limits used to calculate the area of Georgetown Harbour.

river system of concern. For example, the classified zone for the Cardigan River is that area delineated in Fig. 5 lying within the Cardigan River Limits.

Therefore, in Table 3, the classified zone in the Cardigan River actually encompasses the entire river area and is equal to 845.7 hectares with a potential production range from 651.2 to 21479.9 Metric Tons.

Similarly, Table 4 shows the area and production range of several delineated areas in the Brudenell and Montague River Estuary including the area bounded by the Georgetown Harbour. The total area and production range for this region is 1418.9 hectares and 1092.6 to 36041.1 Metric Tons respectively.

Comparing Table 1 and Table 3, the lease production can be up to 15% of the total approved area production. At the extreme end, the total lease production could actually exceed that of the rest of the approved area should the latter be producing at the wild low production rate. This holds true for the Brudenell/Montague River systems as well.

Tables 5 & 6 tabulate the areas of the closure zones as defined by Environment Canada (1988), with a total area of 29.54 ha. In the Brudenell/Montague systems there are 2 areas, one that closes almost half of the Montague River and one that follows the northern shore of Georgetown Harbour. The entire closed areas form a total of 376.3 ha. These latter closure zones are a significant portion of the entire productive area for the Brudenell/Montague area, comprising up to 27% the available growing area. On the other hand, if you look at the entire Cardigan, Brudenell and Montague systems together, the closures represent approximately 18% and the leases themselves only 11.5% of the total classified zone. The leases affected by closure zones of the Cardigan, Brudenell & Montague systems, (see Table 7) represent only 0.3% of the total area and production.

Table 5 - Estimated Potential Production of Selected Shellfish Closure Areas in the Cardigan River Estuary

Shellfish Closure Area Size (ha)	Estimated Production(MT) High 25.4MT/ha	Medium 6.96 MT/ha	Low .77 MT/ha
CARDIGAN RIVER CLOSURE ZONE			
29.54	750.42	205.63	22.75
Grand Totals:			
N: 1			
Sum: 29.54	750.42	205.63	22.75

Table 6 - Estimated Potential Production of Selected Shellfish Closure Areas in the Montague River and Georgetown Harbour

Shellfish Closure Area Size (ha)	Estimated Production(MT) High 25.4MT/ha	Medium 6.96 MT/ha	Low .77 MT/ha
GEORGETOWN HARBOUR CLOSURE ZONE			
86.88	2206.78	604.69	66.90
MONTAGUE RIVER CLOSURE ZONE 1			
289.42	7351.37	2014.39	222.86
Grand Totals:			
Sum: 376.30	9558.15	2619.08	289.76

Discussion

Geographic Information Systems are, by their very definition designed to manipulate data into quickly interpretable information. Further, the data base manipulations and selective data extractions complement the decision support systems that now exist, making them more efficient and comprehensive. Such a system can provide a thorough assessment of closure zones and the potential impacts on the shellfish fishery throughout the Gulf Region and, for that matter, the Maritimes.

On average, fishermen receive from buyers approximately $0.50 / pound for cultured mussels (Gulf Region Statistics Branch, personal communications) (generally oysters will be higher and clams lower, depending on the season and the shellfish quality). The following discussion regarding the value of the shellfish industry applies to the Cardigan, Brudenell and Montague systems. Using the total production values from Table 1 & 2 for the leases, there are 6,594 MT in the High areas.

If 1 MT= aprox. 2200 lbs

Buyers pay approx. $1,100 per MT

therefore 6594 MT x $1,100 = $7.2 million

Applying this value to the shellfish industry in the above mentioned area, the value of the cultured fishery (leases only) can be approximated between $7.2 million at the high production rate and $0.22 million at the low end.

Table 7 - Leases within the Cardigan, Brudenell and Montague River Closure Zones.

Lease Number	Owner	Owner Address	Lease Location	Area (ha)	Estimated Production(MT) High 25.4 MT/ha	Medium 6.96 MT/ha	Low .77 MT/ha
M-0287	(Classified data)	Georgetown, P.E.I. C0A 1L0	Georgetown	4.63	117.6	32.21	3.56
M-0295	(Classified data)	Lower Montague, P.E.I. C0A 1R0	Montague	10.3*(2.25)	261.6(57.2)	71.65(15.7)	7.93(1.73)
			Closure Totals	14.93	379.2(174.8)	103.9(47.9)	11.49(5.29)

* 2.25 ha are in the closure zone and 8.065 ha are unaffected by closure

Table 8 - Report on Agricultural Activities in the Cardigan, Brudenell and Montague River

Type	Watershed	Location	UTM Coordinates
BEEF	BRUDENELL-CARDIGAN		529100.0,5115800.0
BEEF	BRUDENELL-CARDIGAN		528500.0,5117800.0
BEEF	BRUDENELL-CARDIGAN		526200.0,5117700.0
DAIRY	BRUDENELL-CARDIGAN		527400.0,5120600.0
DAIRY	BRUDENELL-CARDIGAN		524100.0,5117100.0
DAIRY	BRUDENELL-CARDIGAN		524800.0,5117500.0
DAIRY	BRUDENELL-CARDIGAN		530800.0,5118500.0
DAIRY	BRUDENELL-CARDIGAN		537300.0,5114800.0
DAIRY	BRUDENELL-CARDIGAN		537100.0,5114600.0
FOX	BRUDENELL-CARDIGAN		537600.0,5114700.0
HOGS	BRUDENELL-CARDIGAN		537400.0,5114700.0
HOGS	BRUDENELL-CARDIGAN		529100.0,5115500.0
HOGS	BRUDENELL-CARDIGAN		528500.0,5117800.0
HOGS	BRUDENELL-CARDIGAN		525100.0,5117200.0
HOGS	BRUDENELL-CARDIGAN		527600.0,5120800.0
HOGS	BRUDENELL-CARDIGAN		524300.0,5122100.0
BEEF	MONTAGUE	LOWER MONTAGUE	529000.0,5112100.0
DAIRY	MONTAGUE	UNION ROAD	523500.0,5113600.0
FOX	MONTAGUE	LOWER MONTAGUE	534100.0,5112200.0
FOX	MONTAGUE	MONTAGUE	527000.0,5113800.0
FOX	MONTAGUE	BRUDENELL	529600.0,5113400.0
FOX	MONTAGUE		525300.0,5110900.0
FOX	MONTAGUE		525400.0,5110700.0
HOG	MONTAGUE	LOWER MONTAGUE	530800.0,5112500.0
TOBACCO	MONTAGUE	BRUDENELL	531000.0,5118000.0

N: = 25

* Data provided by Environment Canada, Inland Waters, Water Planning and Management, Atlantic Region

Obviously, not all shellfish leases produce at the same rate and a reasonable estimate could be the Medium estimate of $1.98 million.

If, using the formula:

Approved Zone - Leases = Wild

and the wild production rate is closer to the Low value, then the value of the wild shellfish fishery is in the order of $1.6 million. However, the nature of this wild fishery is recreational for public use and probably never realizes this market value. The cultured operations alone are potentially of more economic value than the wild fishery. The wild fishery, on the other hand, is probably more valuable aesthetically than the culture operations. The closure zones impact more on the wild fishery than on the leases and effectively remove $0.34 million (roughly 21% of the entire value for the classified zones ... see results on page 7) whereas the leases that lie within the closure zones were estimated (using the medium production rate) to have a

Fig. 7. Map of the Cardigan, Brudenell and Montague River Systems showing the locations of known and possible pollution sources such as effluent discharge pipes, farms and dump sites within their watersheds. Note the proximity of leases to some of the outfalls.

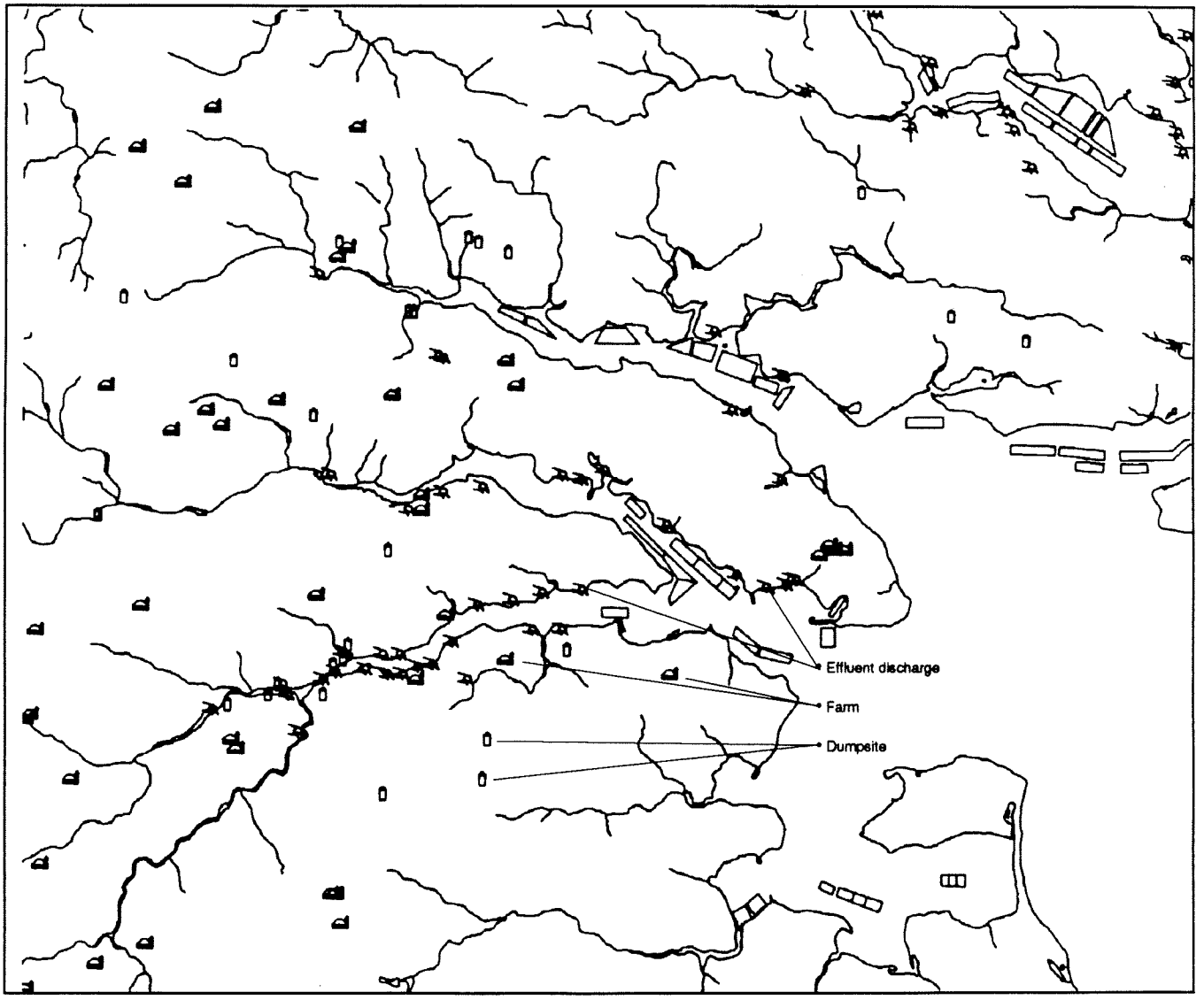

Table 9 - Report on known and potential pollution sources in the Cardigan, Brudenell and Montague River

Prov	UTM Coordinates E.	N	Source Type	Description
PE	527100	5112100	R	Stormwater drainage near Rt.4 bridge
PE	526400	5111800	DR	Drainage at highway bridge
PE	536300	5118200	LE	Small general store with ST/DF - approx.30m
PE	534950	5119100	LE	Group of four cottages with ST/DFs - pprox.75
PE	527000	5120250	LE	Cardigan Fish Culture Station: - ST/DF for
PE	529500	5118550	LE	Four-unit Motel with ST/DF - approx.20m from
PE	529400	5118600	LE	Service station and Salty Dog Seafoods Ltd.
PE	535300	5117500	LE	Group of 10 cottages with common - ST/DF at
PE	536300	5116100	LE	Group of three cottages with - ST/DFs located
PE	534000	5115200	LE	Group of six cottages at Doctor's - Point;
PE	532750	5116300	LE	Brudenell Campsite trailer dumping station;
PE	532300	5113900	LE	Group of four cottages; ST/DFs - approx.20m
PE	531500	5113850	LE	Group of four cottages; ST/DFs - approx.25m
PE	530900	5113700	LE	Group of seven cottages; ST/DFs - approx.30m
PE	530200	5113600	LE	Group of five cottages; ST/DFs - approx.20m
PE	528650	5112600	LE	Group of two cottages; ST/DFs - approx.30m fro
PE	528300	5112600	LE	Group of eight cottages; ST/DFs - approx.30m
PE	526300	5112000	LE	Group of five small homes along - (<20m) shore
PE	528400	5112200	LE	Group of four cottages; ST/DFs - approx.30m
PE	528700	5112200	LE	Group of six cottages; ST/DFs - approx.25m fro
PE	529000	5112350	LE	Group of four cottages; ST/DFs - approx.20m
PE	529300	5112400	LE	Group of five cottages; ST/DFs - approx.25m
PE	529700	5112850	LE	Group of seven cottages; ST/DFs - approx.30m
PE	531300	5113100	LE	Group of five cottages; ST/DFs - approx.20m
PE	531900	5113100	LE	Group of four cottages; ST/DFs - approx.20m
PE	535400	5114200	LS	Lift Station with 24in CSP overflow pipe;
PE	531900	5116200	NP	General runoff and recreational access from
PE	527250	5116200	NP	Farm near Dewars Pond; no evidence of animal
PE	528800	5115500	NP	Tobacco Farm; possible contamination from
PE	529500	5115850	NP	Tobacco Farm; possible contamination from
PE	530300	5115950	NP	Tobacco Farm; possible contamination from
PE	524900	5111500	NP	Surface runoff to Knox Pond
PE	536500	5114100	PI	Marine Harvesting Ltd. aquaculture plant;
PE	526600	5111050	RI	Valleyfield River; numerous agricultural
PE	536600	5114100	TP	Georgetown waste stabilization pond:
PE	532300	5116100	TP	Brudenell Park treatment system: extended
PE	527500	5112650	TP	Langley Fruit Packers treatment system:
PE	527950	5112300	TP	Montague Wastewater treatment system:
PE	536400	5114000	WV	Georgetown Shipyard; three vessels present a
PE	536000	5113950	WV	Coast Guard Marine Terminal; two vessels
PE	527350	5112250	WV	Montague wharf; 15 vessels present
PE	530000	5112100	XX	Cardigan Regional Sanitary Landfill:

* Data provided by Environment Canada, Environmental Control Branch, Industrial & Shellfish Programs Division, Atlantic Region.

value of only $52,690.

This does not mean that the shellfish leases within the closure zones are minimal and that the closure zones do not have a significant impact. The closure zones are increasing, not decreasing, in their extent and it may not always be a result of fecal coliform concentrations. Culture operations are going to increase as well and the search for suitable habitat will have to be done so as to give the potential operator all possible chances to succeed.

Rather than treating the symptom of polluted waters and contaminated shellfish by simply restricting fishing activities, resource managers and regulators would probably most like to examine the possible sources of the problems, much of which are land-based, and attempt to mitigate the problem at the source. Figure 7 shows the land-basedwastewater discharges, farms and dump sites as represented by symbols on the map. The data received from Environment Canada did not include all the data that are associated with each pollution source.

Tables 8, 9 and 10 are reports generated from the data received from Environment Canada. As can be seen, the data have corresponding UTM coordinates which facilitated placing the symbols on the lease base maps and their spatial relationships could be quickly determined. The colour version of this map differentiates the types of activities. The farms are distinguished as to whether they are dairy, pig or poultry by their colour on the map. The effluent discharge pipes are also coloured to be distinguished by their effluent type. The dump sites are colour classified as to whether they are operational, closed or destined for clean-up.

The sources of the various types of effluent can allow managers to pin-point potential problem areas and conduct further investigations. Mapping water sources, drainage, topography, geological structures and land use can further allow managers to work with proponents and owners of these sites to mitigate and altogether prevent contamination.

The major problem in the realization of the use of a Geographic Information System is the cost involved in its implementation. The actual purchase of a system can range between $25,000 (in 1991 dollars) for a PC version with limited capabilities to a full blown mainframe system costing over $1 million. However, anyone within the industry will maintain that the purchase of the system is only the up front visible cost. The true cost and the value of the system lies in

Table 10 - Report on Waste Disposal Sites in the Cardigan, Brudenell and Montague River

Location Code	Watershed	UTM Coordinates	Approved	Active	Priority	On-site Hazards:
KA16	CARDIGAN-BRUDENELL	528400.0,5114700.0	NO	NO		
K55	CARDIGAN-BRUDENELL	526900.0,5117400.0	NO	NO	1	CHEM CONT OS; NEAR SURFACE WATERWAY
K46	CARDIGAN-BRUDENELL	530000.0,5121000.0	YES	YES	1	CHEM CONT OS; NEAR SURFACE WATERWAY
KA3	CARDIGAN-BRUDENELL	527400.0,5120900.0	NO	NO	2	CHEM CONT OS; NEAR SURFACE WATERWAY
KA35	CARDIGAN-BRUDENELL	528900.0,5119500.0	NO	NO	2	NEAR SURFACE WATERWAY
KA42	CARDIGAN-BRUDENELL	530200.0,5120900.0	YES	YES	2	NEAR SURFACE WATERWAY
K43	CARDIGAN-BRUDENELL	539700.0,5119400.0	NO	NO	3	
K47	CARDIGAN-BRUDENELL	530800.0,5120700.0	NO	NO	3	
KA14	CARDIGAN-BRUDENELL	537900.0,5121900.0	NO	NO	3	NEAR SURFACE WATERWAY
KA41	CARDIGAN-BRUDENELL	528800.0,5119500.0	YES	YES	3	
K56	MONTAGUE/VALLEYFIELD	527600.0,5112800.0	NO	YES	1	CHEM. CONTAINERS ON SITE; NEAR SURFACE WATERWAY
KA28	MONTAGUE/VALLEYFIELD	527500.0,5112500.0	NO	YES	1	
KA26	MONTAGUE/VALLEYFIELD	526200.0,5112000.0	NO	YES	2	SITE LOCATED CLOSE TO SURFACE WATER
KA36	MONTAGUE/VALLEYFIELD	528300.0,5109800.0	NO	YES	2	SITE LOCATED CLOSE TO SURFACE WATER
KA37	MONTAGUE/VALLEYFIELD	530400.0,5110900.0	NO	YES	2	CHEMICAL CONTAINERS ON SITE
KA43	MONTAGUE/VALLEYFIELD	525200.0,5111600.0	NO	YES	2	CHEM. CONTAINERS ON SITE; NEAR SURFACE WATERWAY
KA7	MONTAGUE/VALLEYFIELD	532000.0,5112700.0	NO	YES	2	CHEMICAL CONTAINERS ON SITE
K57	MONTAGUE/VALLEYFIELD	525300.0, 51.1e+06	NO	YES	3	
K60	MONTAGUE/VALLEYFIELD	530300.0,5110100.0	NO	YES	3	CHEMICAL CONTAINERS ON SITE
KA27	MONTAGUE/VALLEYFIELD	527300.0,5112400.0	NO	YES	3	CHEMICAL CONTAINERS ON SITE
KA29	MONTAGUE/VALLEYFIELD	527100.0,5111800.0	NO	YES	3	
KA30	MONTAGUE/VALLEYFIELD	526000.0,5111800.0	NO	YES	3	

n:=22

* Data provided by Environment Canada

the capture, storage and availability of the data. What is missing in many government departments is the infrastructure to implement and provide real-time data to the users who have access to such a system. For example, to provide this demonstration, data were collected from many sources, from maps digitized for the domoic acid crisis of 1987 and shellfish lease information from the Gulf region's Resource Allocation Division, with data from 1987 and 1988, much of which were not in digital form and had to be entered manually. Further, data for the closures and approved shellfish zones were taken from 1988 publications from Environment Canada which include the UTM coordinates of the land reference points defining the approved, conditional and closed classification. The data on pollution sources also came from Environment Canada as an ASCII digital file from an off-line computer data base. Acquisition, reformat and data entry were the costs of conducting this mini-project and the total came to over $9,000. If all of these data points were in digital format on a data base, these zones could quickly be plotted and made available on an ad hoc basis by the end-user at a much lower cost.

The project was further limited by the hardware available to run the GIS and the lack of personnel (only two individuals were available to collect, reformat, enter and manipulate these data and prepare the report). Further monies were required to hire a data entry clerk and acquire and transport computer equipment to present a demonstration of the project at the Bedford Institute of Oceanography (B.I.O.) in March 1990.

The New Brunswick government, at the prompting of its Department of Fisheries & Aquaculture, has initiated an Memorandum of Understanding on data exchange with DFO, specifically for the use within their Geographic Information System. They have been given the responsibility for managing and allocating the shellfish and aquaculture leases in the Province and they would like to have the data on the shellfish leases that the Department has already digitized. This can already give an indication that data, when properly managed and organized, are a valuable asset and a GIS makes those data even more valuable.

Recommendations:

One of the major problems encountered in this study was the diversified and inconsistent nature of data that exist within DFO and elsewhere. An agency or Department wishing to pursue a GIS management strategy must put into place the required financial and human infrastructure to support the data capture and data base management. Below are the steps that must be taken to implement any program that is to use a GIS:

First: define the problem.

Second: determine the data that are required to solve the problem.

Third: ascertain the sources of the data (those organizations, agencies or government departments whose mandate it is to collect the data) and its format.

Fourth: evaluate the data compatibility, quality and completeness.

Fifth: negotiate the availability of the data and transfer formats .

An agency / department such as DFO must look seriously at its data acquisition and encourage the proper use of data base management systems to store and disseminate its data. Too many data are tied up in spreadsheets, makeshift ASCII data storage formats and in 'hardcopy only' format. Much survey and cruise data sit in hardcopy or data discs because the scientist has not had time to massage, edit, or publish the data. Although the data may not be of immediate value to the scientist, or it may be of secondary importance to the actual research, it may be valuable to another agency or scientist.

A system must be developed to give the collecting scientist or manager proper credit for the use of his data in much the same way that credit is given for publications. This issue is essential since much of the data are considered proprietary and not available because technical or other publications have not been completed. This can seriously delay the release of data and jeopardize the value of real-time ad hoc queries to a GIS The credit system could be such that the more users there are of the data, the more valuable the data become and it could conceivably approach the value of a primary publication. This could, in turn, encourage scientists to massage and make their data available sooner.

The actual GIS purchased is irrelevant as long as it meets the needs of the manager and the end-user for map and data presentation and manipulation. However, whatever system is acquired or in use, the agency / department must allocate sufficient resources (financial and human) to its function and operation in order for it to be effective. This resourcing cannot be overlooked and the system cannot be run casually like a word processor or spreadsheet operation. It is labour and time intensive but in the end, the results in time savings and the thoroughness of data analysis justify the expenditure.

Conclusion

Geographic Information Systems are being increasingly used in managing resources and data. A GIS can be used, as defined by this pilot project, for the determination of the effects of closure zones on the shellfish industry (or other human impacts on any other resource industry). It is, however, essential that the infrastructure to deal with the collection and dissemination of large amounts of data must first be in place.

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