ASSESSING SHELLFISH CULTURE CAPABILITY IN COASTAL BRITISH COLUMBIA:

Sampling Design Considerations for Extensive Data Acquisition Surveys

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Preface

This report is submitted to the Resources Committee (RIC) by the Coastal Task Force.

The Resources Inventory Committee members are resources inventory specialists from a wide variety of professional disciplines and representing provincial, federal, aboriginal and private sector agencies and other resource interests. RIC's objective is to develop a common set of standards and procedures for provincial resource inventories.

This completes work initiated by the Ministry of Agriculture, Fisheries and Food in 1992 to develop a standard methodology for determining biophysical capability of marine areas for shellfish (oyster, clam, scallop) culture. This document outlines a recommended approach for acquiring standardized oceanographic and beach assessment information employing an extensive survey approach.

Funding of the Resources Inventory Committee work, including preparation of this report, is provided by the Canada-British Columbia Partnership Agreement on Forest Resources Development: FRDA II. This five-year (1991-1996), $200 million program is cost-shared equally by the federal and provincial governments.

 For additional copies and/or further information about the committee and its task force, please contact the Secretariat, Resources Inventory Committee, 840 Cormorant St., Victoria, BC V8W 1R1; phone (604) 381-5661 or fax (604) 384-1841.

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The Resources Inventory Committee consists of representatives from various ministries and agencies of the Canadian and the British Columbia governments as well as from First Nations peoples. RIC objectives are to develop a common set of standards and procedures for the provincial resources inventories, as recommended by the Forest Resources Commission in its report "The Future of our Forests".

For further information about the Resources Inventory Committee and its various Task Forces, please contact:

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INTRODUCTION

The Ministry of Agriculture, Fisheries and Food has recognized the growth potential of the British Columbia shellfish culture industry, and is taking appropriate steps to clearly define coastal areas which are capable of sustaining shellfish culture. In the identification and evaluation of coastal areas considered appropriate for shellfish culture, the capability and suitability of crown foreshore must be assessed. Where the Suitability of a culture site is determined by those socioeconomic, resource use, infrastructural and marketing parameters which affect the viability of a proposed operation, the Capability of a shellfish culture site refers strictly to environmental parameters and mitigators which will affect the ability of a site to support the proposed culture.

The environmental parameters which are considered important in establishing Site Capability have been presented and discussed by Cross and Kingzett (1992) in a document outlining the "Biophysical Criteria for Shellfish Culture in British Columbia: A Site Capability Evaluation System". Considered as potentially limiting environmental factors, they comprise:

Temperature
Salinity
Dissolved Oxygen
pH
Food Availability
Fetch (Wave Height)
Suspended Sediments
Tidal Flow (Water Movement)
Prevalence of Disease
Fouling Organisms
Predators
Substrate (for beach culture)
Slope (for beach culture)

The biophysical parameters listed above can and should be employed to determine whether a site is capable of sustaining a specific commercial shellfish operation. The order in which the variables are presented (above) does not imply a hierarchy of importance, or ranking; any one or a combination of these factors could influence the capability of a site to support a particular type of shellfish culture.

As an initial step in the process of evaluating Site Capability is the collection of biophysical information appropriate to the area which is to be assessed.

Information required in establishing site capability for shellfish culture can be acquired employing extensive or intensive data acquisition approaches. Where intensive methods will acquire detailed spatial and/or temporal data on all (or a subset) of the variables affecting the growth and survival of a particular shellfish species in a specific location, an extensive data collection approach will provide general "trends" for those oceanographic properties determining site capability on a broader spatial scale. Parameters employed in an extensive survey will provide a gross spatial delimitation of areas considered capable of sustaining

shellfish culture, but will not necessarily identify specific sites within these areas where shellfish culture facilities might ideally be located.

EXTENSIVE SURVEY SAMPLING RATIONALE

The extensive data acquisition approach is an appropriate first stage method for obtaining information on shellfish culture capability for a particular region.. The shellfish culture capability parameters most suited to this survey approach include:

Salinity
Temperature
Relative exposure (fetch: distance/direction)
Beach slope/composition (in the case of beach culture).

The first 3 parameters, which jointly describe the physical oceanographic properties of the survey area, will typically vary the greatest (spatially and temporally) within a coastal region. The range of values recorded for these key variables will best determine site capability for each specific shellfish species for which an appraisal is being conducted. These parameters are equally important for the overlying waters which affect beach culture areas as they are for deepwater areas surveyed for suspended culture potential.

The fourth extensive survey parameter, beach slope/substrate composition, provides a specific evaluation of the features considered key to the assessment of intertidal habitat for the bottom culture of either the Pacific oyster or the Manila clam. In an extensive survey, an evaluation of these features, which must be acquired during periods of low tide, will provide information on beach status prior to any culture efforts. In evaluating these features, it must be realized that marginally acceptable beach conditions (in terms of substrate) may be compensated for through the use of appropriate husbandry techniques. The extensive survey is intended only as a cursory examination of an entire region, and as such does not evaluate each of the beaches with respect to mitigation potential; this approach should be left for an intensive survey approach, when a specific site is under consideration for culture purposes.

Each of the physical attributes described above will directly influence the capability of an area to support various types of shellfish culture. Employing proper survey techniques these parameters alone can provide an adequate, albeit gross information base upon which a regional appraisal of shellfish culture capability could be made.

The following subsections discuss survey design considerations and the minimal information which should be acquired to conduct a regional, extensive shellfish culture capability appraisal.

Survey Parameters

As discussed above, the parameters most appropriate for a regional assessment of shellfish culture capability include water temperature, salinity, relative exposure, and (in the case of beach culture) substrate composition and beach slope. Although a summary of historical data collected for these oceanographic and physical attributes would intuitively provide the most cost-effective source upon which to base a shellfish culture capability appraisal, the majority of coastal waterways in British Columbia distinctly lack the historical water quality information necessary to provide such an evaluation. Where historical information has been collected the survey purpose has been sufficiently different so as to make these data somewhat inappropriate for a shellfish culture capability assessment. Nearshore, coastal oceanographic surveys have historically described water column properties, typically relating offshore currents and upwelling processes to fisheries resources, primary/secondary productivity, etc. Very few of these studies have been conducted within the protected inlets and channels of west and northeast Vancouver Island, or within the waterways comprising the central coast of this province. Although much more information has been acquired for areas within the influence of the Strait of Georgia, the shellfish industry within this region is well developed and would require little in the way of exploratory surveys to identify appropriate growing areas.

Historical oceanographic data (When available) have also been obtained in efforts to describe the characteristics of entire water columns. In these surveys, no effort has been placed on examining any one section of the water columns. In these surveys, no effort has been placed on examining any one section of the water column, particularly that of the surface waters. However, in order to achieve the objective of appraising coastal regions for shellfish culture capability, it becomes necessary to thoroughly understand the physical oceanographic characteristics of these surface waters. Although entire water column information can provide valuable information on stratification, tendencies for upwelling of bottom waters, etc., the extensive survey, designed solely for evaluating coastal regions for shellfish culture potential, must concentrate on describing the portion of the water column which will ultimately influence both growth and survival of each respective shellfish species considered for culture. To provide a cost-effective survey for acquiring oceanographic information on a regional basis, the following sampling considerations are discussed prior to providing a survey design considered appropriate for a regional (extensive) shellfish culture capability evaluation.

Spatial Oceanographic Sampling Considerations

To obtain adequate temperature-salinity (T-S) information for a coastal region under examination, sampling profiles must be acquired vertically (profile) at fixed stations positioned along a horizontal (waterway) transect. The information acquired by carefully defining spatial T-S changes is integral to the delimitation of areas capable of sustaining shellfish culture.

Water Column Profiles

Vertical water column profiles will provide depth information on the location and magnitude of thermoclines and pycnoclines for the area under examination. For deepwater culture these

data will determine to what depths suspended culture could be established; for beach (bottom) culture, these data will provide important information on the surface water characteristics which will directly affect the intertidal shellfish stock during periods of high tide.

Establishing Horizontal Gradients

For an extensive survey water column profiles should be conducted horizontally along mid-channel transects which will result in an adequate description of the salinity-temperature changes which occur along such a transect. As most coastal inlets and channels are affected by the influx, tidal dispersion and dilution of freshwater, spatial sampling of water column profiles along a horizontal transect is an important consideration in an extensive survey design. This aspect of the spatial sampling program, in conjunction with the vertical profiles, will identify how freshwater inputs are entrained within the marine receiving water, and thus where low salinity environments may prohibit shellfish culture.

In addition to delimiting the mixing of freshwater within each of the marine waterways under examination, the spatial sampling aspects of the extensive survey program will identify important water temperature gradients which may also limit the success for particular types of shellfish culture. As many of the coastal waterways include poorly flushed embayments and inlet systems, low or elevated water temperature resulting from local circulation characteristics represent an important, potentially limiting environmental attribute in the shellfish culture capability appraisal. A proper spatial sampling component will assure that any such gradients are identified within each of the waterways surveyed.

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Temporal Oceanographic Sampling Considerations

Fluctuations in oceanographic conditions will occur temporally as well as spatially. Vertical profiles and horizontal gradients of temperature and salinity will be directly affected by tidal activity (short-term temporal changes) and by seasonal (long-term) temporal changes. The

combination of these temporal influences on water column temperature and salinity will have a pronounced influence in the implementation of a proper regional (extensive) shellfish capability evaluation.

Short-Term Temporal Changes

Tidal exchanges will directly affect the structure of water column salinity and temperature profiles and any one particular sampling station. Local circulation dynamics will vary from ebb to flood tides, thereby changing the spatial influence of freshwater intrusion, temperature gradients, etc. Although an intensive, site-specific survey should evaluate the T-S changes which occur across a number of tidal cycles, the effort required to conduct such profiles over an extensive sampling area would prove prohibitive.

Although there are advantages in defining profile characteristics for each tidal direction, it is recommended that effort be placed on determining spatial T-S profiles during the ebbing tide. Given that the net surface flow is outward during this period of the tidal cycle, establishing vertical oceanographic patterns during this period will delimit the maximum dispersion of freshwater input from each coastal source. In effect, this survey approach will also provide information on the dispersion and extent of a freshwater lens which is not disturbed through any flood tide upwelling/mixing process (providing no wind-induced mixing is present). An estimate of the magnitude (vertically and horizontally) of these surface freshwater intrusions, as a result of appropriate short-term temporal monitoring, will provide important information regarding the spatial limitations for shellfish culture within a given coastal waterway.

Seasonal (Long-Term Temporal Changes

The most significant changes in oceanographic properties of the water column will occur seasonally. With spring freshets, freshwater input to the marine system will be at maximum levels while water temperatures will remain low following the winter period. Describing water column profiles during this season will ensure that the spatial extent of freshwater intrusion is adequately identified.

During the summer months water temperatures, particularly within the surface waters, will achieve an annual maximum. Freshwater inputs, in contrast, will typically be at a minimum with no substantial rainfall events occurring during this period of the year.

Although oceanographic sampling on a regular, perhaps monthly basis, is ideal for an intensive site survey, this sampling frequency is somewhat prohibitive for an extensive survey design. It is recommended, however, that attempts be made to sample each sampling station at least twice; once during the summer, when water temperatures are the highest and freshwater inputs are highest and water temperatures the lowest. Incorporation of these sampling periods, as a minimum, within an extensive survey design will ensure that seasonal extremes are reported for each of the areas examined.

Relative Exposure

The relative exposure of a potential shellfish growing area will have a direct influence on whether the area is capable of sustaining commercial culture activities. The exposure of an area can be defined as the extent to which it is affected by wind and wave action. Substantial

movement of shellfish stock within suspended culture apparatus, or the physical disruption of beach areas considered for bottom culture, will each (differentially) affect the survival and/or potential growth of the various commercial shellfish species.

In an extensive survey, relative exposure can be established by estimating maximum fetch and the direction of that fetch. As an approximate measure, each can be determined directly from the appropriate hydrographic chart, and thus require no field verification for extensive survey purposes. In a final evaluation of a specific culture site (intensive survey), a much more thorough analysis of the wind and wave action should be completed.

For an extensive survey of potential deepwater culture areas, waterway exposure can best be estimated as the fetch along the longest axis for a particular reach. For beach culture, the fetch at the beach centre is considered adequate for this type of survey. Reference to Environment Canada regional climatological information will subsequently permit an evaluation of estimated exposure data in terms of predominant wind directions and velocities. For example, a large fetch at a particular site may not necessarily be of concern for a potential shellfish site if the predominant winds for that region do not follow the same track.

Beach Slope & Substrate Composition

The physical characteristics of a beach, in addition to the overlying water quality and site exposure, are important features to consider in the shellfish capability evaluation. For an extensive survey, beach slope and substrate composition can be readily documented during a quick low-tide excursion. From one end of the beach, a photograph should be taken perpendicular to the fall line and slope estimated once this photograph has been developed. The photographic record also provides documentation of any visual observations made during the on-site survey.

Visual assessment of a beach should include a brief description of substrate composition, identifying primary types (e.g., mud, sand, pea gravel, boulder, etc.) for each tidal level (high, mid and low). Presence of algal mats (e.g., eelgrass) and any obvious macroinvertebrates should also be noted for the subsequent shellfish capability evaluation.

EXTENSIVE SURVEY SAMPLING DESIGN

Employing the sampling rationale discussed above, the following **Extensive Survey** design is proposed as a cost-effecitive approach for acquiring sufficient information with which to appraise coastal areas for shellfish culture capability. This design represents the recommended minimal effort, and in no way should be considered appropriate for assessing specific sites (leases) for shellfish culture potential.

Survey Parameters

The following parameters are considered appropriate in an extensive survey for shellfish culture capability.

- salinity
- temperature
- relative exposure (fetch; distance/direction)

- beach slope/composition
- beach slope/composition
  (in the case of beach culture).

Survey Frequency (Temporal Sampling):

Oceanographic parameters (salinity-temperature) should be acquired twice within a single year; once during the summer and once in late winter or early spring.

An on-site survey of each beach area should be conducted during a single summer low-tide period (adequate low tides within the winter months are during the night and would thus prohibit an adequate survey).

Relative exposure can be assessed once for each deepwater readh and once for each beach area surveyed.

Spatial Sampling:

Water quality profiles to establish salinity-temperature gradients should be acquired with an appropriate data-logging or a real-time CTD meter. Data should be collected from the surface to the bottom (in shallow areas) or to a maximum depth of 50 metres along main channels. Information should be summarized for depth intervals of 0.5 metres and examined for evidence of a distinct pycnocline and/or thermocline. Incorporation of these data into a database can be accomplished by further condensing the information, i.e., reporting CTD for standard profile depths, e.g., surface, 2, 3, 5, 10, 15, 20, 25, 35, and 50 metres.

Profiles should be established along waterway centrelines at a horizontal interval of no greater than 1.0 nautical mile (nm). At the heads of inlets or near significant areas of freshwater intrusion, this sampling interval should be reduced to 0.5 nm in an effort to define the spatial impacts of these freshwater-marine mixing areas. For small embayments at least one central profile should be established to document oceanographic conditions away from the adjacent, main waterway.

EXTENSIVE SURVEY - DATA COMPILATION

Acquisition of oceanographic and physiographic information relevant to the appraisal of shellfish culture, on a regional basis, will result in a substantial collection of data in a format readily adaptable to a database archive. In particular, use of a common sampling design for each coastal region surveyed will permit a standardized set of parameters to be compiled for each station within each of the regions surveyed. The following text provides a description of the structure suggested for an appropriate information database for the shellfish culture capability survey data.

Water Quality Profiles

The position of each sampling station should be recorded with geographical coordinates (latitude and longitude). Use of a standardized presentation format for each sampling station will ensure that collected positional information is compatible across all regions surveyed, and will thus make development of an electronic coastal database relatively easy.

Each station should be coded with an alphanumeric location parameter which is associated with actual geographical coordinates (decimal minutes). The code (e.g., CWQ-001) can thus refer (and describe) the region surveyed (C=Clayoquot), identify the record as a water quality entry (WQ), and associate the numeric descriptor (e.g., -001) with that of a sampling station located at 49^{o} 7.55' N and 125^{o} 48.67' W.

Each of the water quality data records should also include fields for time of sampling, summarized for shellfish capability by Summer versus Winter surveys; for example 06/92 and 10/69, respectively. Sampling method should also be provided, thus giving some indication of data precision/accuracy for future reference.

Water quality profile information should be summarized for a set of standardized depths, thus making database values comparable across all records. Depths recommended include surface (0 metres), 2, 3, 5, 10, 15, 20, 35, 35, and 50 metres. Missing data should be represented with a numeric code within the database (e.g., 0.00 or 999) which will permit them to be eliminated from any graphical summaries which might be extracted from the coastal database.

Beach Surveys

Similar database records should be constructed for beach survey information. Much like the water quality database structure, the beach survey database should include a station code field, and the geographical coordinates of the beach. Each record should also incorporate an estimate of beach exposure, which includes the direction in which the beach faces (e.g. 123 through 208^{o} True), as well as an estimate of maximum fetch in nautical miles (nm). Beach slope should be provided as a ratio (e.g., 15:1 or 15 metres horizontal to every 1 metre in elevation) and a brief description of the beach substrate composition (e.g., firm to soft mud; eelgrass present). To indicate the water quality characteristics which most likely influence the beach during high tide periods, a reference to the water quality station codes (e.g., CWQ-001, 002) should also be provided as a "cross-reference" field within each BEACH record; these stations should represent the closest set of water quality stations sampled for the beach area evaluated.

SHELLFISH CULTURE CAPABILITY APPRAISAL

The information collected through an appropriate, extensive survey can be subsequently employed in an appraisal of shellfish culture capability for the region in question. The data obtained using the generic sampling program described above will provide general "trends" for those oceanographic properties determining site capability on a broader spatial scale. Although the parameters employed in an extensive survey will provide a gross spatial delimitation of areas considered capable of sustaining shellfish culture, they will not necessarily identify specific sites within these relatively large areas where shellfish culture facilities might ideally be located.

It is highly recommended that shellfish culturists use the results of an extensive survey only as a guideline to site selection. Should a specific area within a given waterway be considered attractive as a potential shellfish culture site, the culturist is well advised to implement an intensive sampling program at the site to provide a much more accurate evaluation of the potential of the site for the culture of shellfish.

An intensive site survey should acquire spatial and temporal information on each of the parameters used in the extensive survey, but should also incorporate all of those parameters (14; see page 1 of this document) which might limit the capability of the site to support shellfish culture. Sampling over an entire year, at monthly intervals (minimum), will provide a relatively detailed record of seasonal changes in growing water characteristics at the site, and will clearly suggest which species of shellfish (if any) might not be appropriate for culture within that particular area.

The intensive site survey also provides the grower the opportunity to assess the site in terms of shellfish culture suitability. The proximity to potentially conflicting coastal foreshore uses (e.g., sources of contamination), or the location of a site with respect to loading facilities, supplies, etc. (operational constraints), each represent suitability considerations which will preclude the capability of the site to support the culture of shellfish.