A Technical Review of the Conservation Utility Analysis: Issues and Recommendations for Future Analyses

M.M. Manson

Oceans, Habitat and Enhancement Branch
Fisheries and Oceans Canada
200 – 401 Burrard Street
Vancouver, British Columbia
V6C 3S4

2008

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2774

Fisheries and Oceans   Pêches et Océans

Canada

Canadian Manuscript Report of Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1–900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 901–1425 were issued as Manuscript Reports of the Fisheries Research Board of Canada. Numbers 1426–1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux or régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au suject; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classes dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 900 de cette série ont été publiés à titre de manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Manuscript Report of
Fisheries and Aquatic Sciences 2774

2008

A TECHNICAL REVIEW OF THE CONSERVATION UTILITY ANALYSIS: ISSUES AND RECOMMENDATIONS FOR FUTURE ANALYSES

by

M.M. Manson

Oceans, Habitat and Enhancement Branch
Fisheries and Oceans Canada
200 - 401 Burrard Street
Vancouver, British Columbia
V6C 3S4

Cat. No. Fs 97-4/2774E ISSN 0706-6473

Correct citation for this publication:

Manson, M.M. 2008. A technical review of the Conservation Utility Analysis: Issues and recommendations for future analyses. Can. Manuscr. Rep. Fish. Aquat. Sci. 2774: iv + 16 p.

TABLE OF CONTENTS

ABSTRACT

Manson, M.M. 2008. A technical review of the Conservation Utility Analysis: Issues and recommendations for future analyses. Can. Manuscr. Rep. Fish. Aquat. Sci. 2774: iv + 16 p.

The Conservation Utility Analysis (Ardron, 2005) was reviewed with respect to its analytical approach and the individual data sets that were used in the analysis. Issues with the rationale for including a data set, data processing, data quality, and information gaps were identified in eleven data sets. The selection of input data sets is the major driver of the analysis and should be considered openly. Issues with data processing and quality did not likely have a strong influence on the results of the CUA, although it is recommended that the issues be rectified before including the data sets in future analyses. Further recommendations are put forward to be considered in any future Marxan based marine planning analyses.

RÉSUMÉ

Manson, M.M. 2008. A technical review of the Conservation Utility Analysis: Issues and recommendations for future analyses. Can. Manuscr. Rep. Fish. Aquat. Sci. 2774: iv + 16 p.

L'analyse de service de conservation (Ardron, 2005) a été passée en revue en termes de son approche analytique et différents ensembles de données qui ont été employés dans l'analyse. Des issues avec le raisonnement pour inclure un ensemble de données, le processus, la qualité de données, et les lacunes de l'information ont été identifiées dans onze ensembles de données. On l'a conclu que les issues n'ont pas probablement eu une influence forte sur les résultats du CUA, mais on lui recommande que les issues soient rectifiées avant comprenant les ensembles de données dans de futures analyses. D'autres recommandations sont proposées d'être considéré dans toutes les futures analyses de planification marines basées par Marxan.

1.0 INTRODUCTION

The Conservation Utility Analysis (CUA) was completed in June 2003, to identify areas of high conservation utility which would be useful for marine planning initiatives on the BC coast (Ardron, 2005). The analysis was completed by the Living Oceans Society, to comprise the marine portion of the Coast Information Team (CIT) Ecosystem Spatial Analysis, which had been established as part of the Central Coast LRMP Phase 1 framework agreement (CIT, 2004).

The major conclusions of the CUA identified areas of high conservation utility in the Central Coast (e.g. Hexactinellid Sponge Reefs; Goose Islands, Bardswell Islands and vicinity; Rivers Inlet; Scott Islands; entrance to Queen Charlotte Strait, etc.), North Coast, Queen Charlotte Islands, and NW Vancouver Island. The approach to the analysis received considerable critical review through its predecessor, the Central Coast Pilot Study (LOS 2002), and many of the recommendations were incorporated into the CUA. The CUA itself was reviewed less extensively (e.g. CUA Review Meeting, Nov. 28, 2005; Evans et. al. 2004; LOS 2002), but has been widely complemented as a comprehensive analysis representing the forefront of GIS analytical technique.

Ardron (2005) provides a detailed description of the rationale and methodology for the analysis. Marxan software, which was central to the analysis, is a conservation planning tool which selects a suite of areas that meet given conservation targets with spatial efficiency. It is described in more detail elsewhere (Ball and Possingham 2000, Possingham et. al 2000).

In very general terms, the analysis involved:

1. The identification and digital representation of 93 *conservation features* which would be biologically and physically important to marine conservation goals (e.g. representivity, distinctiveness, focal species, and rare or threatened species) (Ardron, 2005). Much of this data was gathered from existing sources.
2. The delineation of the study area into hexagon-shaped, 500 hectare *planning units*. In total 32,000 planning units were used to represent the study area.
3. Assigning a value for each conservation feature to each planning unit. The abundance value tells Marxan the amount of a particular feature contained in each hexagon. Depending on the conservation feature, this could be a presence-absence score, or could include a relative importance weighting for the feature. The score was weighted to account for the proportion of seawater covered by the hexagon.
4. For each conservation feature, assigning a *target* for conservation (e.g. a minimum percentage of a habitat type) and a *penalty value* for not attaining the target.

5. Using the simulated annealing algorithm in Marxan to select a set of planning units that meet the target value for each conservation feature while minimising the overall “cost” (i.e. area) of the selected solutions.
6. Twenty-four scenarios were run, using six different proportional targets (e.g. 5%, 10%, 20%, 30%, 40%, and 50%) and four unique *boundary length modifiers*. The *boundary length modifier* controls the degree of clumping in the solution. The selection process was repeated 100 times for each scenario, producing 2,400 unique solutions.
7. A selection frequency was then allocated to each planning unit. These frequency values were displayed in a “summed solution” map with a colour gradient from blue to pink to yellow, according to the number of times they were selected by Marxan in each of the 2,400 runs. Planning units with the highest number of selections were considered to have the highest “Conservation Utility.”

This review was initiated as part of an agreement between Fisheries and Oceans Canada and LOS in 2005. The review focuses on technical GIS issues, with particular emphasis on the general approach to the analysis and the individual data sets that comprise the conservation features in the CUA. Larger issues, such as how appropriate this kind of analysis is to marine planning in BC are not addressed. Items were evaluated on 1) the rationale for following an analytical approach or including a data set, 2) the processing steps followed in preparing a data set for analysis, 3) inconsistencies present in a data set, 4) quality issues with the source data, and 5) possible information gaps. The strengths or technical issues with these criteria that may be of concern to Fisheries and Oceans Canada, are presented and recommendations for further analysis are provided. The report is intended to provide direction to any future analyses that may be undertaken using the data sets created during the CUA, or following the CUA approach.

2.0 CUA REVIEW

2.1 ANALYTICAL APPROACH

Output from the analysis was summarized in a single summed solution map, labelled as "Conservation Utility" by LOS. As previously mentioned, the summed solution map displays the selection frequency value of each planning unit. In effect, this indicates the relative importance of the planning unit to meeting the conservation targets specified in the analytical scenario. It is also useful for prioritizing areas to be given initial consideration for conservation. However, it does not in itself propose what a final MPA network might look like. Rather, it points out those areas that recur under varying conditions. The conclusions of the CUA are consistent with this narrative, though the output could be improved by the following:

1. Additional information could be gained by also presenting the results from each of the 24 different scenarios separately. This would demonstrate the effect that decisions (e.g. target value, boundary length modifier) can have on potential solutions. Additionally, the scenario maps would focus attention on the utility of the analysis as a modeling tool, alleviating any impression that the output is a proposal for protected area boundaries. If this approach were taken, perhaps fewer scenarios should be presented.
2. The output should be complemented by additional maps showing the *best solution* for each scenario. Best solution maps show the outcome with the most efficient solution out of the repeated runs executed for each scenario (e.g. in the CUA, 100 iterations were run for each scenario). These maps would provide insight into the amount of area necessary to meet the targets and constraints for each scenario. However, it should be noted that best solutions do not indicate how important (i.e. interchangeable) individual areas are to the overall solution. Thus, best solutions should always be considered in combination with the summed solution.
3. The selection of conservation features is obviously essential to the overall value of the analysis. While the features included in the analysis are a reasonable set, additional features, as data become available, would likely benefit the analysis (e.g. areas of primary productivity, ocean gyres, areas of upwelling, and perhaps recently created catch summaries). A more transparent selection process would strengthen the analysis.
4. Future versions of Marxan (i.e. Marzone) will include the ability to target features in different management zones (e.g. fishing, low-impact, no-take). The analysis will no longer be focussed on "protect or not" dichotomy, and will enable the development of more realistic planning scenarios.

2.2 INDIVIDUAL CONSERVATION FEATURES

Although the planning units were assigned a value for 93 conservation features, many of these were simply different categories of the same feature (e.g. 21 categories of substrate/depth). This review identified 22 unique features which were generated in a congruent method or derived from independent data sets (Table 1).

The CUA report described the rationale for including each feature, generally including a citation for the data source, although the source citation was missing for the Regional Representation and Steller Sea Lion features. With the exception of the anadromous streams by magnitude feature, detailed metadata was not included in the report (Ardron, 2005). A recommendation for metadata documentation has been included in the final section of this report to address this issue in future analyses.

In order to assess the features, metadata for each feature was obtained and, in conjunction with a visual quality assessment of the source data, the methodology for processing steps was reviewed. Quality and accessibility of the metadata varied, but LOS were extremely forthcoming with any outstanding information and made every attempt to address the information gaps identified during the review.

Table 1. Source of metadata used for each conservation feature dataset.

	Layer	Metadata Source
1	Stream Richness x Magnitude	CUA Appendix 2
2	Sea Lion Haul-outs	LOS Sea Lion Notes
3	Bird Capability	LOS Bird Capability Notes
4	Seabird Colony	LOS Seabird Colony Marine Usage Notes
5	Small Islets	LOS Small Islets Notes
6	Large Corals	LOS Coral Notes
7	Herring Spawn	LOS Herring Spawn Notes
8	Moulting Seaducks	LOS Moulting Seaducks Data Notes
9	Substrate/Depth	BC MEC (MSRM 2002), BC Shorezone Mapping (Howes et. al. 1997, Searing and Frith, 1997)
10	Ecological Regions	BC MEC (MSRM 2002)
11	Current	BC MEC (MSRM 2002)
12	Ecosection	BC MEC (MSRM 2002)
13	Regional representation	LOS pers. comm.
14	Complexity	Ardron (2002)
15	Hexactinellid Sponges	NRCan
16	Eulachon Estuaries	DFO
17	Red-Blue Estuaries	LOS pers. comm.
18	Biobanding	BC Shorezone Mapping (Howes et. al. 1997, Searing and Frith, 1997)
19	Sea Otter	LOS pers. comm.
20	Eelgrass Polygons	LOS pers. comm.
21	Kelp	LOS Kelp Metadata2 Document
22	Shoreline Exposure	BC Shorezone Mapping (Howes et. al. 1997, Searing and Frith, 1997)

In total, eleven data sets were reviewed with no issues, and eleven were reviewed with issues identified (Table 2). The issues identified from the assessment are described in detail for each data set in the subsections below.

Table 2. Conservation features with data source reviewed and issues identified, or no issues identified.

Data Reviewed with No Issues Identified	Available Data Reviewed with Issues Identified
Ecosection	Anadromous Stream Richness x Magnitude
Regional representation	
Complexity	Large Coral
Hexactinellid Sponges	Herring Spawn
Eulachon Estuaries	Sea Lion Haul-outs
Red-Blue Estuaries	Moulting Sea Ducks
Bird Colonies	Bird Capability
Biobanding	Small Islets
Sea Otter	Substrate/Depth
Eelgrass Polygons	Ecological Regions
Kelp	Current
Shoreline Exposure	

2.2.1 Anadromous Stream Richness X Magnitude

Streams (from the 1:50,000 scale Watershed Atlas) supporting anadromous fish were assigned a score according to the number of anadromous species present (as recorded in FISS), and the relative size (measured as the number of source tributaries) of the watershed. The representation of fish distribution has been an ongoing issue in BC, and this analysis, like others, was limited by the quality of the available fish distribution information. Considerable effort was expended to rectify data quality issues that were found in the FISS data points. A further series of edits were required to prepare the BC Watershed Atlas stream network to seamlessly link to the points. The achievement was a technical triumph, though several issues have been identified below.

1. Representing a system by a single hexagon (or occasionally splitting it between two) at the mouth of the river is not an accurate spatial representation of the marine habitat that the anadromous species of a system inhabit. The rationale for this approach was limited by the CIT decision to consider separately terrestrial, nearshore, and marine analyses (i.e. it was believed that estuaries would be considered in the CIT nearshore analysis, and that watersheds would be considered in the

CIT terrestrial analysis; river mouths were identified in the marine analysis with the general understanding that these represented "anchor points" linking to the other two analyses). While it is acknowledged that these points could link to marine areas of high value to anadromous species that may be spatially represented by other features in the analysis, a better approach may be to directly include areas of high value (e.g. migratory routes, holding areas, etc.). The inherent difficulty of spatially representing anadromous species likely necessitates the use of broader planning processes for the conservation of anadromous species (e.g. Wild Salmon Policy implementation, detailed Coastal Management Area plans) that integrate terrestrial and nearshore objectives.

2. Based on several inconsistencies found in the overlaid datasets, a quality control tactic was implemented where at least two FISS points had to be present on the stream to be assigned a measure. This resulted in 30% of the streams being dropped (i.e. 470 of the 1590 streams with at least one FISS record), which is likely an overly cautious approach.
3. The measure disregards small streams, particularly where few species have been recorded. While the intent of this approach was to not allow weak data to falsely direct the overall analysis, this decision is of particular significance to coho, which tend to favour small streams for spawning and rearing. Coho habitat, particularly for coastal coho stocks in the region, is thus likely being under represented. For example, in the Queen Charlotte Islands, only 22 of 153 coho distribution points for streams have been included. In contrast, 30 of 62 chum distribution points for streams are captured.
4. The final measure (ranging from 1-20 in PNCIMA) was multiplied by 9, a step not described in Appendix 2 (Ardron, 2005). Interestingly, the hexagon with the highest score was at the mouth of the Bella Coola River, because the hexagon intersected both the Necleetsconay River, with a measure of 9 and the Bella Coola River with the score 16 ((9+16) x 9 = 198). The Skeena and Nass Rivers scored 180.
5. Magnitude (essentially a count of all source tributaries in a watershed) tends to be higher in areas with steep topography. For example, on Graham Island (relatively flat), the Yakoun River has a magnitude of 60 and total stream length of 304 km. In contrast, the Kloiya River has magnitude 63 and length of 121. So magnitude does not necessarily reflect the quantity of available habitat.
6. The magnitude measure does not account for accessible or useable habitat. For example the Kloiya River (magnitude 63, length 121 km) has 66 km inaccessible to anadromous species due to an impassable obstruction. Possible alternative measures of magnitude should be investigated (e.g. length of stream within a specific gradient range, length below impassable obstruction) depending on data availability.

2.2.2 Habitat Forming Corals

The coral layer was based on records of coral occurrence from 11 different agencies, compiled by the Marine Conservation Biology Institute as part of the Baja to Bering Marine Conservation Initiative (B2B) in 2002. Many of the records from the CIT study area originate with the Canadian Museum of Nature. The B2B data was widely distributed and reviewed, and at the time of the CUA, would certainly have been the best available data of its kind.

For the CUA, a density analysis was performed on the point locations, and the results were classified into six equal intervals. To ensure that the most concentrated sites would contribute to the analysis, only the four densest classes were included, in effect removing single point observations from the data set.

1. Since completing the CUA, an analysis of observed bottom trawl bycatch records (Ardron and Jamieson, 2004) has identified 12 areas of high coral concentration. There is considerable overlap between the two data sets, though some areas are unique to each one. The observed bycatch concentrations should be considered for use in future analyses.

2.2.3 Herring Spawn

Herring spawn habitat index points were obtained from DFO. To rectify some issues with positional accuracy (e.g. many of the points did not intersect a shoreline), 91% of the points were snapped to the centroid of herring shoreline segments that were created as part of various coastal resource inventories in the 1990's. The remaining 9% of the points were left in their original location. A density analysis was then performed on the points with a 750 meter decay radius.

1. The editing procedure was very time consuming, and certainly created a clean data set, representing the linear nature of the data with reasonable accuracy. However, given that the herring spawn database is updated annually, and future analyses will likely have to incorporate the new data, it may be more efficient to accept the spatial accuracy of the original data, and perform the density analysis on the original points.
2. Since completion of the CUA, herring spawn polygons from 1930 to 2002 have been digitized for coastal BC and are available for download on the internet at:
   http://www.pac.dfo-mpo.gc.ca/sci/herring/herspawn/pages/default6_e.htm
   Two main issues will limit the use of this data in future analyses: 1) the polygons are not quantitative, and cannot be linked to the quantitative records, and 2) a significant proportion (30%) of spawn records could not be digitized, so the data is not intended for use at scales that would extend beyond approximately 10km (McCarter et. al. 2005).

2.2.4 Sea Lion Haul-outs

Steller sea lion haul out & colony data were obtained from DFO (PBS), UBC (Andrew Trites) and Local Ecological Knowledge (one point, South Central Coast). A density analysis of population points from 1987, 1992, 1994, and 1998 was performed and the results were classified into five classes. Similar to the coral data, the lowest class was discarded to ensure that the most populated sites, with lowest inter-annual variability would contribute to the analysis. This resulted in 1/3 of the points (i.e. any haul-out with population fewer than 70) being dropped. The resulting sea lion layer closely matches the layer being considered as part of the Ecologically and Biologically Sensitive Areas project for the Pacific North Coast Integrated Management Area (PNCIMA).

1. In cases such as this, where a decision has been made to remove areas of lower importance, the decision should be verified by experts.

2.2.5 Moulting Seaducks

Data from two sources (CWS, 2003 and Savard, 1988) were merged, a transformation was performed, and relative importance values assigned. The source surveys captured information differently, one representing population estimates on linear segments of shoreline (CWS 2003), the other as point locations (Savard 1998), which presented a challenging problem to rectify. The strong solution derived by LOS was verified by CWS (LOS, pers. comm.), and is another valuable product from the CUA analysis.

1. The method for assigning relative importance to the transformed values was somewhat more complicated than that chosen for other features. Although it was a mathematically sound approach, future analyses, which may be presented to a broad audience, could benefit from a simpler approach.
2. 31% of the scoter observations and 26% of the harlequin duck observations were assigned RI value of 0. This decision was verified by CWS.

2.2.6 Bird Capability

Three general bird capability features were created: pelagic species, shorebirds, and waterfowl, representing areas where flocks of birds are likely to be found. Marbled murrelets were also created as a separate feature. The data were provided from three sources: (1) Decision Support Services, Ministry of Sustainable Resource Management, province of BC (inventoried by two contractors in different file structures and classifications); (2) Jacqueline Booth & Associates, based on Berger et. al. 1997 and interviews; and (3) Canadian Wildlife Service, Critical Waterfowl Habitat. The combination of these data sets, and resolution of the relative importance scores to a consistent scale, was done in a logical and arduous manner, but suffers from a broader problem with data standards, that has been the scourge of many analyses of natural inventory data.

1. Due to inconsistencies among the data sources, a different approach was required to resolve the relative importance scores for each of the four features. Many decisions had to be made to assign values to a common scale. While not completely subjective in nature, these decisions could not be made according to a predefined model, and were potentially strongly influential on the output. Possibly a more consistent approach would be to have 2 scores: known high value, and uncertain value.

2.2.7 Small Islets

In order to compensate for gaps in the bird surveys, which did not cover small islets, islets of .025 to 250 hectares were extracted from the TRIM coastline, and assigned a relative importance value based on the length of their shoreline. A density analysis was performed on the line work, which spreads the relative importance value over a 1km radius.

1. Other factors (e.g. height and wave exposure) would influence the importance of a given islet or concentration of islets.
2. The density analysis was effective in highlighting areas where many small islets were concentrated, but also had the effect of spreading the importance of less concentrated areas over the 1km search radius. While these areas were assigned a low relative importance, it seems unlikely that they would perform the same ecological role as areas of higher concentration. There is also some inconsistency with the treatment of these low importance areas compared to other features, where areas of low importance were often dropped (e.g. sea lion haul-outs, moulting seaducks).

2.2.8 Substrate/depth

Twenty-one classes of depth, substrate, and ecological region (i.e. inlets, passages, shelf, slope) data were defined and hexagons were assigned a value for each, according to the proportion of each class in the planning unit. Unique depth classes were defined for each region, based on ecologically relevant values taken from various literature sources.

1. There is general agreement among the CUA author and other reviewers (e.g. LOS pers. comm., Perry in LOS 2002) that the quality of the substrate data is poor (albeit the only PNCIMA-wide data source that existed in a workable format at the time of the analysis). The source of the substrate data is the BC Marine Ecological Classification (LUCO 1997, AXYS 2001, MSRM 2002). The BC MEC is an analytical product, derived from several different input data sets, the sources of which are not always clear. For example, the source of the substrate and current is not cited in the available BC MEC report (MSRM, 2002). Further discussion of issues with the BC MEC is beyond the scope of this report, but its quality and

scale has been criticised in detail elsewhere (Ardron 2001). In future, better sources of substrate data should be sought from NRCan.

2. There are instances where hexagons have a complete presence value (i.e. 16) for more than one substrate/depth class. Eg. Hex 14505 (in Telegraph Passage) has Unknown Depth (7) = 16, Passage Sand not Photic (200025) = 16 and Inlets Sand not Photic (300025) = 16.

2.2.9 Ecological Regions

The study area was divided into six general marine physiographic types: inlets (very small, small, and medium to large), passages, continental shelf, and continental slope. These regions were delineated based on exposure, salinity and mixing data extracted from the BC MEC (LUCO 1997). A 1997 Parks Canada analysis and some local knowledge (LOS pers. comm.) were also incorporated.

1. Ian Perry (in LOS 2002) recognised the boundaries between regions as important and questioned how the boundaries were defined.
2. Some features were classified counter-intuitively. For example, Princess Royal Channel transitions from the channel class to medium inlet at Graham Reach (Figure 1). Grenville Channel also transitions to small inlet. This was due to mixing and freshwater influence in the area (LOS pers. comm.), but the classifications have not been independently verified.
3. Due to the previously identified issue with the quality of the BC MEC, there is agreement with the CUA author that expert input from IOS relating to salinity and mixing in these areas should be sought (LOS pers. comm.).

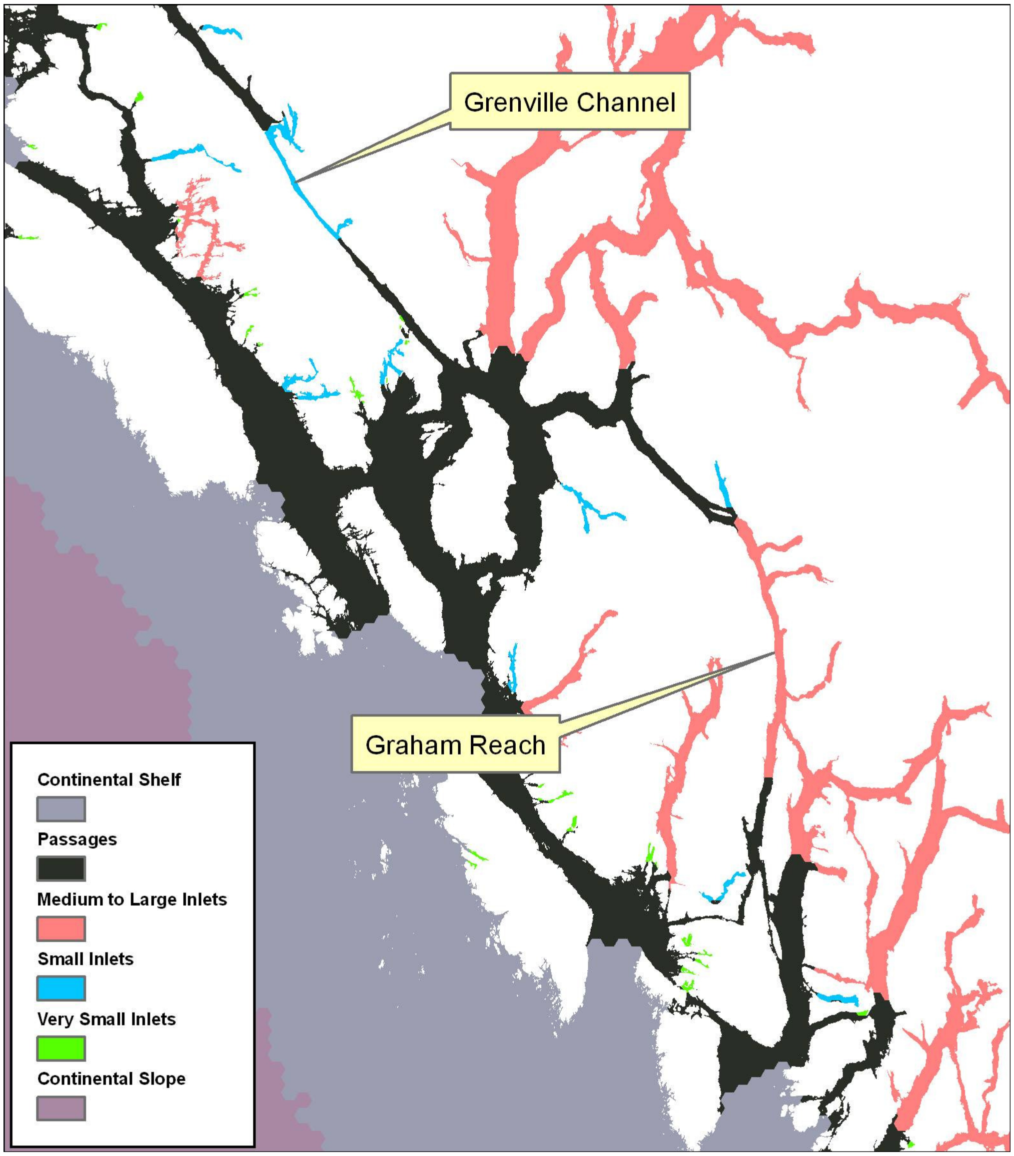

Figure 1. Example areas of interesting ecological region classification.

2.2.10 High Current

Data were extracted from the BC Marine Ecological Classification (LUCO 1997, Axys 2001). Some local knowledge was also incorporated.

1. Some areas of known high current are conspicuously absent in the BC marine ecounits dataset (e.g. Nakwakto Rapids are not classified as high current, though they have the highest measured tidal current speed in the world (Thompson 1981)). Although this area of high current was added to the feature in the CUA analysis, it again calls into question the reliability of the current data in the BC MEC dataset. Expert input from IOS should be sought for better current data (LOS pers. comm.).

2. The high current areas don’t match the high mixing areas in the BC MEC dataset. Again this calls into question the reliability of the BC MEC data, and further underscores the importance of obtaining better current data from IOS.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The technical GIS issues that have been identified in this review should provide direction to strengthen similar marine planning analyses in the future. The analytical approach to the CUA was sound, but could have benefited from more exhaustive documentation of the input data sets, their selection, and individual scenario results. Data processing and quality issues do not substantially take away from the value of the CUA as it stands. Due to the fact that: 1) many of the issues are relatively minor, and 2) the output was restricted to the presentation of the selection frequency values which tallied the results of 24 scenarios, it is unlikely that addressing the data processing and quality issues alone would create significant differences to the results. However, where future analyses may consider using one or more of these data sets, remediation should be considered prior to using the data.

In order to avoid or minimize technical GIS issues in future analyses (using Marxan, its successors, or other approaches), and create the most valuable and defensible product for integrated marine planning, the following recommendations are proposed.

1. Extracting data from generalized or potentially degraded sources (e.g. BC Marine Ecological Classification) should be avoided if at all possible. In these cases, the original data sources, or alternate data sources should be sought.

2. Careful attention must be afforded to the documentation of each data set. Original data sources, quality issues and processing steps must be provided in detail. This metadata should be recorded and maintained according to industry standards and presented as appendices to the analysis.

3. An approach to identify the set of conservation features should be developed, whereby potential users of the analysis can identify possible features and measure them against a predefined set of criteria (e.g. availability, scale of feature, data quality, various ecological roles).

4. Results should be presented separately for individual scenarios.

5. The summed solution output should be complemented by additional maps showing the *best solution* for each scenario.

6. The expanded capability that is anticipated for future Marxan releases should be incorporated. This capability will dictate how target values will need to be defined for future analyses.

7. Where a portion of a data set has been excluded from the analysis based on low relative importance scores, the decision should be verified by experts on the feature.

8. Relative importance scores should be removed or simplified (e.g. to 2 categories: "Known High" vs. "Unspecified") where a consistent scoring system has not been applied to the original data.

4.0 REFERENCES

Ardron, J., 2001. Review of British Columbia Classification Update, Final Report. Part 1: Issues of Scale, Resolution and Accuracy. LOS electronic document. 11p.

Ardron, J., 2002. A recipe for determining benthic complexity: an indicator of species richness. Chapter 23, Marine Geography: GIS for the Oceans and Seas. Edited by Joe Breman, ESRI Press, Redlands, CA, USA.

Ardron, J., 2005. BC Coast Information Team Marine Ecosystem Spatial Analysis, V. 1.3. Excerpted and revised from Rumsey, C., Ardron, J., Ciruna, K., Curtis, T., Doyle, F., Ferdana, Z., Hamilton, T., Heinemyer, K., Iachetti, P., Jeo, R., Kaiser, G., Narver, D., Noss, R., Sizemore, D., Tautz, A., Tingey, R., Vance-Borland, K., An ecosystem analysis for Haida Gwaii, Central Coast, and North Coast British Columbia. DRAFT, Sept. 22, 2003. 184 p.

Ardron, J., and Jamieson, G. 2004. Reducing bycatch of corals and sponges in British Columbia's groundfish trawl fishery: 12 proposed protection areas.

AXYS, 2001. British Columbia Marine Ecological Classification Update. Final Report. Submitted to Land Use Coordination Office, by AXYS Environmental Consulting Ltd., in association with John Roff, Ellen Hines.

Ball, I.R., and Possingham, H.P. 2000. MARXAN (V1.8.2): Marine Reserve Design Using Spatially Explicit Annealing, a Manual

Burger, A., Booth, J., and Morgan, K. 1997. A preliminary identification of processes and problems affecting marine birds in coastal and offshore areas of British Columbia. Canadian Wildlife Service, Technical Report Series no. 277.

Canadian Wildlife Service, 2003. Coastal Waterbird Inventory in British Columbia – a summary of data from coastal waterbird surveys, 1969-1993: Metadata for Coastal Waterbird Inventory. Provided to the Coast Information Team, Jan. 31, 2003.

Coast Information Team, 2004. About CIT. Online. Internet. Retrieved June 16, 2006 from http://www.citbc.org/abo.html

Evans, S.M.J., Jamieson, G., Ardron, J., Patterson, M. and Jessen, S. 2004. Evaluation of site selection methodologies for use in marine protected area network design. Canadian Science Advisory Secretariat, Research Document 2004/082. 40 p.

Howes, D., Harper, J., and E. Owens. 1997. Physical Shore-Zone Mapping System for British Columbia. Online. Internet. Retrieved June 22, 2006 from http://ilmbwww.gov.bc.ca/risc/pubs/coastal/index.htm

Living Oceans Society, 2002. Conservation Utility Analysis Central Coast Pilot Study: Results of the Expert Review. In Conservation Utility Analysis Review Meeting Materials and Background Information. Living Oceans Society. November, 2005. 107 p.

LUCO, 1997. British Columbia Marine Ecological Classification: Marine Ecosections and Ecounits. Land Use Coordination Office, Otter Bay Coastal Resources, and Coast and Oceans resources Inc. for the Coastal Task Force, Resources Inventory Committee (Version 1).

McCarter, P.B., Daniel, K.S., and Hay, D.E. 2005. Mapping herring spawn. Can. Manuscr. Rep. Fish. Aquat. Sci. 2714: 168 p.

Ministry of Sustainable Resource Management Decision Support Services Branch. 2002. British Columbia Marine Ecological Classification: Marine Ecosections and Ecounits. Version 2. Resources Information Standards Committee.

Possingham, H.P., Ball, I.R., and Andelman, S. 2000. Mathematical methods for identifying representative reserve networks. In: S. Ferson and M. Burgman (eds) Quantitative methods for conservation biology. Springer-Verlag, New York, pp. 291-305.

Savard, Jean-Pierre L. 1988. A summary of current knowledge on the distribution and abundance of moulting seaducks in the coastal waters of British Columbia. Technical Report Series No. 45. Canadian Wildlife Service, Pacific and Yukon Region.

Searing, G.F., and Frith, H.R. 1997. BC Biological Shore-Zone Mapping System. Online. Internet. Retrieved June 22, 2006 from http://ilmbwww.gov.bc.ca/risc/pubs/coastal/index.htm

Thompson, 1981. Oceanography of the British Columbia coast. Can. Spec. Publ. Fish. Aquat. Sci. 56: 291 p.