Evaluation of Large Ocean Management Area (LOMA) options for British Columbia's North-Central Coast

A Report to Fisheries and Oceans Canada

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Executive Summary

As Fisheries and Oceans Canada moves towards implementing Integrated Management in the North and Central Coasts of British Columbia, several options have arisen for the placement of administrative boundaries. In this report we review three proposed boundaries that span the Central and North Coasts, and make note of one other in the Central Coast (Figure 1). From these we have developed two recommendations (Figure 2):

1. The North – Central LOMA should extend from the Alaskan boarder southward to the vicinity of Seymour Narrows, but should *not* include Bute or Toba inlets. Brooks Peninsula should represent the southern boundary on the west coast Vancouver Island. The base of the shelf slope should be the western boundary and the coastal watersheds should represent the eastern boundary.

2. The deep sea offshore region should be treated as one contiguous LOMA. It would span all of BC's deep offshore waters from Alaska to Washington State, and extend from the *base* of the shelf slope seaward to the 200 nautical mile limit of the Economic Exclusions Zone.

Any boundary in the marine realm, no matter how well placed, will contain human activities and ecosystem features and processes that are connected to areas outside of these artificial lines. Consequently, we suggest that regardless of where Fisheries and Oceans decides to delineate its North – Central Integrated Management area, it is imperative that there be administrative mechanisms that link to adjacent planning areas.

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Background

The Canadian Department of Fisheries and Oceans (DFO) is considering boundary options for their Large Ocean Management Area (LOMA) incorporating waters off the North and Central Coasts of British Columbia (Figure 1). Fisheries and Oceans anticipates that the LOMA will fulfill a number of roles including the development of a knowledge framework and a process for planning in localized Coastal Management Areas (CMA). However, while most activities will be planned at the CMA level, it is also anticipated that the LOMA will be the appropriate scale planning process for activities such as oil and gas.

We have been asked to review the current LOMA alternative boundary options and comment on their relative utility. Our role was not to create a completely new boundary, but rather to review strengths and drawbacks of proposed options and suggest logical LOMA breaks based primarily on ecosystem considerations but also based to some extent on practical and administrative realities. Specifically we were asked to:

1. Review and critique current boundary options.

2. Reference information from datasets and publications of both human activities and ecosystem processes and features that should be considered when developing a comprehensive yet sensible boundary.

3. Consider the relative influence of significant human activities and ecosystem processes and features to maintaining ecosystem integrity through reviewing existing literature and discussions with experts.

4. Integrate the important data and information sources and demonstrate the relative utility of each boundary scenario through GIS mapping and analysis.

Marine environments are open systems, and thus distant areas are connected by numerous processes that function at various spatial and temporal scales. Consequently, boundary delineation is always subject to legitimate debate whether some key process is adequately considered by a given boundary. An inherent quality of marine management is the need to consider external or larger scale processes that influence critical parameters and thus management decisions within the boundary. Consequently, we suggest that regardless of where DFO delineates the boundary, it is imperative that LOMA planning include mechanisms that link to other management planning processes in adjacent areas. This will ensure that LOMA resource planning acknowledges and incorporates ecosystem connectivity and neighbouring human activities.

Furthermore, biodiversity conservation requires management that extends beyond spatially delineated boundaries (Salomon et al. 2001). For example, several species at risk under DFO's mandate (COSEWIC 2003) and commercially harvested fish exhibit seasonal migrations and habitat use patterns that transcend all of the proposed LOMA boundaries. Proper conservation of these species requires knowledge of critical habitat use, ecological interactions and key life history "bottlenecks". Spatial management can assist in this by: 1) understanding the locations of key life history processes occurring within the boundary and 2) implementing appropriate management actions that address threats to these. However, such single-species actions may be futile unless implemented in the context of ecosystem based management (EBM).

Spatial management is an important practical strategy to accomplish integrated management and conservation objectives (Zacharias and Roff 2000, 2001). Since resource management is really managing human activities, we first looked at the extent of human **A**ctivities occurring in the North and Central Coasts of BC and then considered the ecosystem **F**eatures and **P**rocess (AFPs) that influence and/or are influenced by those activities. With this in mind, our approach was to suggest possible boundaries options that followed natural ecosystem boundaries, and encompassed numerous relevant AFPs, while attempting to minimize exclusion of important AFPs

Boundary Option Descriptions

We reviewed three boundary options for the North-Central Coast LOMA that are being considered by DFO (Figure 1). The primary similarities among the options were the northern and southern boundaries. All options proposed the Canada/U.S. border in Dixon Entrance as the northern boundary. Similarly, all options proposed Brooks Peninsula on the west coast of Vancouver Island for the southern boundary. There was also general agreement to separate the Johnstone Strait from the Strait of Georgia between mainland B.C. and the east coast of Vancouver Island. However, opinion differed whether to include certain mainland inlets in the North/Central Coast LOMA (Figure 3). Further description of each boundary option is provided below.

The first boundary option was the Pacific Integrated Marine Use Planning Area (PIMUPA) proposed by the national headquarters office of DFO (Figure 1, Table 1).[1] Limited rationale has been provided for this proposal except that the intent of the western boundary was to suggest that the planning area would be generally cut off at the top of the continental shelf (Figure 4). It was felt that the shelf area and the offshore area should be treated as two largely different ecosystems/management areas by virtue of their physical, biological and jurisdictional properties (Darren Williams pers. comm.). The eastern boundary partially included mainland watersheds and sub-watersheds.

The second boundary option proposed by the Pacific Region of DFO is entitled the Pacific North Coast Integrated Management Area (PNCIMA). The western boundary extends beyond the continental shelf to the 200 mile limit of Canada's economic exclusion zone (EEZ). The objective of this broader western boundary was to include several ecosystem (e.g., offshore transport, seamounts, seabirds, fish habitat) and

[1] This option is a modified version of an earlier suggestion, and has extended the western boundary to approximately include the continental shelf.

administrative (shipping, fish management areas, First Nations interests) links between the offshore and coastal areas (Mathias 2004). The eastern boundary includes the majority of the coastal watersheds to ensure terrestrial nutrient loading, salmon migrations and other land/marine ecosystem linkages are considered in LOMA planning. Further, inclusion of the coastal watersheds ensure adherence to federal-provincial agreement to integrate coastal zone management planning (Johannessen et al. 2004). The southern PNCIMA boundary also differed from the PIMUPA proposal since the former excluded both Bute and Toba Inlets. These inlets have oceanographic properties more similar to those in Georgia Strait rather than those further north (Stucchi 2003).

A third boundary option considered, though not originally established as a LOMA proposal, was developed by the Cost Information Team (CIT). The CIT was an independent body set up by the province to provide analyses to the Central Coast, North Coast, and Queen Charlotte Islands Land and Resource Management Plans (LRMP) tables. That said, the CIT boundary does not always follow the LRMP boundaries. Its terrestrial boundary was also determined by other administrative boundaries, notably regional districts, and forest tenures. The southern inclusion of Bute inlet (which is not part of the CCLRMP) was again determined by administrative rather than biological reasons.

The western extent of the Coast Information Team (CIT) marine boundary was intended to follow the base of the shelf slope. The slope base was chosen because the slope biology was determined to be more connected to the shelf than the abyssal plain. For example, many groundfish species will migrate from the shelf to the slope to spawn. The larvae are then carried by onshore currents back up the slope and onto the shelf. Also, it was noted that a number of fisheries occur both on the shelf and the slope, but generally not on the abyssal plain. Thus for biological and socio-economic reasons, the shelf slope was included.

However, at the time the shelf slope base had not been precisely mapped and it was decided that the 2000m isobath would serve as a reasonable proxy. In hindsight, comparing this line (dashed black, Figure 1), with the actual base of the slope (white line) indicates that following the 2000m isobath created a boundary that is unnecessarily convoluted, and often quite different from the actual feature it was intended to represent.

At its northern extent, the CIT marine boundary inadvertently extends into American waters.

Approach

Catalogue of Human Activities and Ecosystem Features and Processes

The lowest stable ecological units are ecosystems, which consist of interacting biotic communities and abiotic environments that occur within a spatially defined area where energy and nutrients are cycled. There are a number of biological and physical features that provide conditions for and define the existence of discrete ecosystems. These include: temperature distribution, salinity, insolation, energy flow, biochemical cycling, and food web structure (GEM Brochure; Garrison, 1999). Ecosystem stability ensures that ecosystem function in terms of processes; goods and services continue to exist into the future. However, BC's marine environment is host to a multitude of human uses, which impose changes, stresses and threats that may destabilise marine ecosystems. These activities and impacts therefore need to be understood and accounted for in marine conservation planning. To help this process, this report identifies the most commonly cited human uses that occur on BC's coast (Appendix 1). These activities occur in an environment of ecosystem features and connecting processes that support ecosystem functions. Features have a relatively restricted spatial range and include species, such as some marine mammals; habitats including seamounts and upwelling areas; and systems, such as salmon dependent streams. Connecting processes include Haida eddies, currents, migration routes, and areas important to marine life stages e.g. spawning and nursery areas. Connecting processes have a wide spatial range and link major ecosystems such as watersheds and coastal areas; estuarine and inner coastal and continental slope; and continental slope and deep sea areas. These major ecosystem categories (watersheds, estuarine and inner coastal, continental slope, and deep sea) represent areas with significant ecosystem differences due to their physical and biological attributes. Appendix 1 catalogues the human activities and ecosystem features and processes identified through literature searches and experience including studies by AXYS Environmental Consulting (2001) for the British Columbia Marine Ecological Classification, and Hanson et al. (2003), who identified and used features and processes to define and delineate ecological boundaries and provide a good source for our catalogue.

Matrix Analysis of AFPs

As noted, features and processes occur over different spatial scales and subsequently have varying degrees of impact on human activities as well as being impacted at different degrees by the human activities. Thus, the third step was to evaluate the spatial range of the activities, features and processes as included within the boundary options. We compared the various boundary options based on the extent they encompassed numerous AFPs in a matrix analysis (Appendix 2). The AFPs included in the analysis were those we identified as being important to consider for LOMA boundary delineation. They included several identified by the proponents of the PNCIMA, PIMUPA, and CIT proposals and several we identified. Further, we considered information presented by

Johannessen et al. (2004 in review) who proposed a boundary for the Central Coast Integrated Management Plan Area.

Five inclusion categories were identified and one was allocated for each AFP/boundary option combination (Table 2). The matrix analysis allowed us to identify differences among the boundary options based on their relative level of AFP inclusion. We identified two general types of differences among the boundaries:

1. inclusion categories differed for a particular AFP between the boundary options, and
2. inclusion categories were the same for a particular AFP but differed in the degree of inclusion.

Once identified, important AFPs that distinguished the boundaries were discussed further in terms of how and why inclusion differed among the boundaries and the relative importance of the AFP (Table 3).

We also graphically demonstrated the relative inclusion of several important AFPs by each boundary. We obtained spatial data for some AFPs and superimposed them onto the various boundary options. Where spatial data was not available, we simply presented graphics outlining the spatial extent AFPs from published documents.

AFP Interrelation

The role of the LOMA boundary is to provide a management area for human activities. Ecosystem features and processes impact human activities that may be carried out in the region as well as being impacted themselves by the activities that occur in the region, thus changing ecosystem function. Management therefore involves accounting for features and processes that influence human activity as well as managing the ecosystem impacts of the human activity through accounting for impacts on ecosystem features and processes. Thus, the fourth step in this analysis was to link the various features and processes to the human activities. This step is outlined in Appendix 3. To help reveal the major differences between the boundary options, Appendix 3 has four sections: activities that occur in the watersheds; estuarine and inner coastal; continental slope; and deep sea, which represent areas with major ecosystem differences. Each activity presented is linked to specific features and connecting process that needs to be considered in marine management. This step was taken to explain the range of impacts from the various activities, and the attributes of the marine environment that may have an impact on the activity.

Results and Discussion

Matrix Analysis

The matrix analysis revealed several differences among the boundary options based on their relative inclusion of numerous AFPs (Table 3, Appendix 2). Predictably, the largest boundary option (PNCIMA), captured the most features and processes. Nine of the most important AFPs we identified were completely accounted for by this boundary option. Further, it also accounted for a larger proportion of AFPs that transcended boundary options. In contrast, the opther boundary options did not completely account for any of our important AFPs. However this goal of inclusivity has to be balanced with focusing on ecological objectives suitable to the LOMA planning scale. For example, some of our groundfish stocks fit into a LOMA scale (e.g. flounder and sole in Hecate Strait), while other fishes such as salmon, span all of BC and into US and international waters. It is inevitable that no matter what option is chosen, certain species and process will not be accounted for. Thus, the objective of a LOMA boundary is not to include everything; otherwise a boundary encompassing the entire BC coast, offshore area and Pacific watersheds would be selected. Rather, the objective is develop a boundary based on ecological principles that strategically includes as many AFPs as possible of that are of a scale suitable for LOMA management.

The following brief discussion is a summary of the relative inclusion in the various boundary options and a description of the importance of only those AFPs we selected as the most relevant (Table 3). A complete comparison of AFP inclusion in the options is provided in Appendix 2.

The inclusion of the coastal watersheds differed, especially in the North Coast, among each option. The PNCIMA option includes far more than the PIMUPA, which includes more than the CIT. Several landuse practices such as agriculture, forestry, and mining can influence freshwater salmon habitat through numerous mechanisms (Meehan 1991). Further, river engineering such as flood protection works, water diversions and impoundments can isolate salmon habitats as well as alter freshwater and sediment flow to estuaries, thus influencing salinity and benthic habitat. Excessive sedimentation associated with terrestrial development can influence both stream and estuarine habitats. Toxins produced in terrestrial and coastal industry are transported downstream and offshore where they can bioaccumulate in marine foodwebs potentially resulting in health problems at higher trophic levels (Ross et.al. 2000; Busbee et al. 1999). Terrestrially derived silica is critical to supporting primary production (especially diatom production) and Mathias (2004) suggests that terrestrial silica also is available to Hexactinellid sponge reef production in Hecate Strait and Queen Charlotte Sound (Figure 5). Elevated nutrient inputs to estuarine systems from agriculture and domestic discharge can degrade benthic habitat and drastically alter benthic foodwebs (Hanson et al 2003).

The boundary options also differ in the degree that commercial fishing activities are included. By excluding the shelf slope, the PIMUPA excludes several important groundfish fisheries that are largely included by the PNCIMA and CIT options. Examples of such fisheries include the sablefish trap fishery (Figures 6, 7 and 8), bottom trawling (Figure 9) and the hook and line fishery (Figures 10 and 11). Unlike the other boundary options, the PNCIMA proposal also includes fisheries (primarily halibut and sablefish, Canessa et al. 2003) occurring on the seamounts.

Potential changes to trophic interactions associated with commercial fishing (e.g., Cox et al. 1999, Martell et al. 2002, Pauly et al. 2002, Jennings and Kaiser 2002) can result in long-term alterations to species composition that may preclude recovery of overexploited species. This can occur at both localized and coast-wide scales. Several species, particularly rockfish and lingcod are vulnerable to reef-specific depletions that may trigger local trophic shifts. Such small spatial ecosystem responses to fishing would be incorporated by all boundary options. However, fishing activities that occur either within or outside of the LOMA boundary can impact foodwebs coastwide since several commercially targeted species migrate in and out of all LOMA boundary options and/or are comprised of populations transcending boundaries. Regardless of the final boundary selection, such ecosystem influences will not be fully incorporated within the boundary for several species. However, fisheries management strategies must consider these external influences in order to ensure maintenance of ecosystem integrity.

Oil and gas tenures in the Queen Charlotte Basin are approximately fully covered by all boundary options (Figures 12 and 13). However, some impacts such as introduction of pollutants, mortality and sensory damage associated with seismic testing can extend beyond the boundaries due to current and eddy transport processes (Cretney et al. 2002, Figure 14) and migration of marine mammals, respectively. By extending to the EEZ, the PNCIMA boundary encompasses more of the potential receiving waters and offshore marine mammal populations that may be impacted.

As alluded to above, several fish species use spatially as well as ecologically divergent habitats throughout their life history. The alternative boundary options include these diverse habitats to varying degrees. For example, halibut and arrowtooth flounder spawn in deep trenches and valleys along the shelf slope (Thompson and Van Cleve 1936; Bailey and Piquelle 2002) with important halibut spawning in Canadian waters occurring south of Cape St. James and North of Cape Knox and Langara Island in Dixon Entrance (Figure 15). Pelagic larvae of both species rely on deepwater currents along the trenches to move to and settle in suitable coastal nursery grounds (Bailey and Piquelle 2002). By excluding the shelf slope, the PIMUPA boundary would not include the important spawning and migratory habitats. Whereas, such areas are partially encompassed by the CIT boundary and fully included in PNCIMA.

Further, the vast majority of out-migrating juvenile salmon from throughout North America follow a common migration route (Figure 16; Welch et al, 2004). Until their first winter, juvenile salmon migrate northwards through the LOMA area occupying waters within a corridor over the shelf and shelf slope. For some stocks, this narrow corridor is followed up to the Aleutian Islands. The PNCIMA boundary fully accounts for this migration corridor north of Brooks Peninsula since the entire shelf and slope are incorporated into the boundary. Whereas, the migration corridor is partially included in both the CIT and PIMUPA boundary options.

Upwelling areas are important habitats for several vertebrates including fishes, seabirds, and marine mammals. This phenomenon brings nutrient-rich bottom waters to the photic zone where high phytoplankton production drives productivity at higher trophic levels. During summer months, north wind-driven surface currents set up conditions for upwelling along the west coasts of Vancouver Island, the Queen Charlotte Islands and off the continental shelf. A variety of seabirds nesting within the LOMA, including COSEWIC listed species (i.e., marbled murrelet and ancient auklet), feed extensively in the upwelling zone (Figure 17). Similarly, several species of whales, including numerous COSEWIC and SARA listed species (i.e., blue whale, sei whale, fin whale, humpback whale, right whale, and various killer whale populations) feed in productive upwelling areas of Canadian waters (Gregr and Trites 2001; Figures 18, 19, 20). The PNCIMA boundary fully accounts for the upwelling zone north of Brooks Peninsula, while it is partially accounted by the PIMUPA and CIT boundaries.

Climatic forcing processes such as El Nino/Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) operate on ocean basin spatial scales and from 7 year to decadal temporal scales, respectively. These processes result in altered ocean thermal regimes that influence primary productivity. Consequently, ENSO and PDO influence productivity of higher trophic levels including several commercially important fish species and federally mandated species at risk (King et al 2000, 2001, Juradao-Molina 2002, Hollowed et al 2001). Indicators of these processes are inside and outside the various boundaries but since the PNCIMA boundary extends furthest offshore, more indicators exist within that boundary. Regardless of the final boundary, we need to further understand these processes so that we can develop improved predictions of fish recruitment and survival responses that can be incorporated in ecosystem based management of fish stocks.

Two seamount ranges occur off the continental shelf: 1) the northern range comprising 7 seamounts, including Bowie Seamount off the coast of the Queen Charlotte Islands, 2) the larger southern range consisting of 10 seamounts off the coast of Vancouver Island (Figure 21). Recently, we have started to improve our understanding of the ecological significance of seamounts off the British Columbia coast. In particular we have enhanced our knowledge of Bowie Seamount since it has been proposed as a marine protected area (Canessa et al. 2003). This seamount contains abundant groundfish populations that are commercially exploited. Genetic evidence suggests that yelloweye rockfish on Bowie are from the same populations as those along the inner coast. Transport mechanisms such as currents and eddies (i.e., Haida and Sitka, Figure 14) likely bring larval fish from inshore and shelf waters to Bowie (Canessa et al. 2003). Divergent theories exist whether Bowie acts solely as a sink or also as a source for coastal sablefish. Several birds and marine mammals also feed at Bowie. The PNCIMA boundary proposal includes all northern seamounts in Canadian waters but excludes the southern range. The PIMUPA and CIT options exclude all seamounts.

Boundary Analysis

We have developed general boundary recommendations for the North/Central Coast LOMA based on consideration and amalgamation of the various AFPs presented (Figure 2). We did not select the PNCIMA option outright despite it inclusion of more AFPs owing to it larger size. In fact we did not recommend any of the boundary options as they were presented to us. However, we did agree with portions of all boundary options considered. We based our recommendations primarily on logical separation of ecological gradients, but also on administrative realities. We also tried to ensure our suggested boundary included as many important AFPs as logistically feasible. And where relevant to ensure comprehensive ecosystem-based management, we highlighted the need to link North/Central LOMA planning to external resource management.

The Northern Boundary should be the Canada/U.S. border at the north end of Dixon Entrance. This line is not a suitable ecological boundary, but its choice is clearly driven by the jurisdictional limit of the Canadian federal government. However, since numerous AFPs transcend this boundary, sound ecosystem based management requires that DFO continue and enhance their engagement in transboundary resource planning. Currently, DFO engages in species-specific transboundary planning through vehicles such as the International Pacific Halibut Commission and the Pacific Salmon Treaty. We encourage DFO to broaden transboundary planning to more comprehensively incorporate ecosystem-scale links between Canada and the U.S.

The western LOMA boundary should extend to the base of the shelf slope (Figure 2) since a fundamental topographic and ecological break exists between slope and abyssal regions. Seafloor habitat features that influence fish community structure such as slope and complexity decreases rapidly from the slope base to the abyssal plain. Upwelling driven productivity makes both the outer shelf and shelf slope area important summer feeding grounds for numerous mammals, birds, and fish relative to waters overlying the abyssal plain. Both the shelf and shelf slope are important habitats for many groundfish during their life history. For example, the slope and associated trenches are important spawning and larval migration habitats for halibut and arrowtooth flounder. Neither of these species utilize abyssal regions during any part of their life-cycle. Adult sablefish restrict their use of abyssal regions to midwater migration between the continental shelf and seamounts (Kimura et al. 1998). The shelf and slope comprise the primary migration corridor for juvenile salmon prior to moving offshore after their first winter. From a management perspective, the slope base represents the primary outer extent of major commercial fisheries including sablefish, hook and line (rockfish and halibut), and trawl.

The major features excluded from the LOMA by placing the western boundary at the base of the shelf slope are the seamounts. While the seamounts are ecologically connected to shelf and coastal waters, we felt the ecological differences were sufficient to warrant a boundary. The major connecting processes linking seamount to coastal waters are unidirectional, from the coast outwards to the seamounts via Haida and Sitka eddies and prevailing currents (Cretney et al. 2002; Robinson et al. 2004). It is becoming apparent that coastal and inshore stocks contribute to Bowie fish populations; however, there is conflicting evidence whether the reverse is true (Canessa et al. 2003). In fact, the abyssal region separating the shelf from the seamounts may be a barrier preventing large-scale migrations of adult groundfish, with the exception of sablefish noted above.

Further, we felt splitting the off-shelf/deep ocean area into two management areas as implied by the PNCIMA proposal was unjustified. This area should be considered as a single LOMA extending from the northern to southern Canada/U.S. border and from the base of the shelf slope to the 200 mile EEZ limit. There are too many AFPs that are contiguous in this area that warrant a single off-shelf/deep ocean LOMA. These include, but are not limited to:

1) Whale migrations and habitat use,
2) Shipping,
3) Upwelling-primary production occurs throughout this offshore area in summer,
4) All seamounts, both northern and southern ranges, should be in the same LOMA.

We emphasize the need to establish this off-shelf/deep ocean LOMA and to ensure it is linked will inshore and coastal planning processes

We agree with Johannessen et. al. (2004) regarding the general location of the southern boundary (Figure 3). On the mainland and east coast of Vancouver Island, Johnstone Strait (JS) should be separated from the Strait of Georgia (SoG). Temperature, salinity and current differences, and minimal mixing of JS and SoG waters (i.e., most SoG water exists via Strait of Juan de Fuca) suggest a clear and defensible ecological break (Thomson 1981). The high population density around SoG and associated management issues also suggests a sound administrative break. We agree with Johannessen et al (2004) and Mathias (2004) in excluding Toba and Bute Inlets. These inlets are oceanographically more similar to those in the SoG (Stucchi 2003) since their waters primarily exchange with SoG.

We further agree with Johannessen et al. on the west coast of Vancouver Island that the boundary should extend from Brooks Peninsula (BP) to base of shelf slope. Summer coastal oceanographic conditions south of BP differ from those to the north since the summer northern buoyancy current high in fresh and warmer water flowing out of Juan de Fuca Strait heads outward at BP (Figure 22). A topographic break also occurs at BP. The shelf significantly narrows at BP, widening again to the north and south. BP also represents a useful management break since the bulk of the Canadian hake fishery occurs south of this peninsula (Figure 23).

The eastern LOMA boundary should include the coastal watersheds to accommodate land/marine linkages into the planning area. Using watersheds and sub-watersheds as planning units is common practice in terrestrial conservation (e.g., Noss et al 2002, Sky Islands 2000), and this approach was also taken in the recent Coast Information Team analysis, using what were called "Ecological Drainage Units" (Rumsey et al 2003). Most of BC's LRMP boundaries also follow (or are intended to follow) watershed boundaries. However, because mainland watersheds can be very large, often an arbitrary decision is made at which sub-watershed to draw the line.

The landward side of the CCIM boundary was, in principle, defined by watersheds (Johannessen et al. 2004 in review). However, the actual extent of watersheds in the North and Central Coasts is vast, and no boundary captured them all. To accommodate the expanded North Coast – Central Coast LOMA, Johannessen and Mathias continued from the CCIM proposal northward, again following watersheds, but including in the North a larger proportion than had been captured in the Central Coast. This boundary forms the easternmost component of the PNCIMA. Because this line is representing a *marine* boundary, it is difficult to determine if managing this large a terrestrial area is tractable or not. Presumably, only riparian activities such as streamside logging or road building would be considered. Topographically, however, this area much more accurately represents the drainage basin, capturing all of the BC Nass and most of the Skeena basins, and as such better accounts for the upstream aquatic influences than previous North Coast boundaries.

Recommendations and Summary

Based on the three North Coast – Central Coast LOMA boundary options provided to us, as well as the Central Coast IM proposal, we make the following two recommendations:

1. The North – Central LOMA should extend from the Alaskan boarder southward to the vicinity of Seymour Narrows, but should *not* include Bute or Toba inlets. Brooks Peninsula should represent the southern boundary on the west coast Vancouver Island. The base of the shelf slope should be the western boundary and the coastal watersheds should represent the eastern boundary.

2. The deep sea offshore region should be treated as one contiguous LOMA. It would span all of BC's deep offshore waters from Alaska to Washington State, and extend from the *base* of the shelf slope seaward to the 200 nautical mile limit.

Rationale

North – Central Large Ocean Management Area

We feel there is ample biological and oceanographic evidence to argue that the shelf slope (and gullies) is more connected and akin to the shelf than to the abyssal plain. Upwellings, bird feeding areas, and groundfish spawning migrations all occur within this convergence between shelf and slope. Furthermore, the largest fisheries in BC (bottom and midwater trawling) both utilize waters over the shelf and the slope, as does the sablefish fishery and groundfish hook and line. Thus, we suggest that the shelf slope and shelf should be treated together, as done in principle by the CIT, and as better defined by the CCIM proposal.

The southern boundary with the Strait of Georgia is an obvious biological, oceanographic, and managerial break. However, the exclusion of Bute and Toba inlets might not appear so obvious to those who are unfamiliar with the oceanography of these inlets. On a standard map they visually resemble other inlets in the Central and North coasts. Looking at their underwater profile (shaded relief map, Figure 3) helps to clarify why these two inlets belong in the Strait of Georgia; namely, their strong connectivity to that water body.

All of the boundary options given to us used Brooks Peninsula as a boundary feature on the West coast of Vancouver Island. We agree with this choice; but we note the lack of other options presented to us. We agree with the intent of the CIT and CCIM boundaries to extend only so far as the base of the shelf slope. We recommend the use of the CCIM line as far as it follows the base of the slope, and to continue this line northward along the slope base to the Alaskan boarder.

All of the proposals at least somewhat followed watersheds or sub-watersheds, though to differing accuracy. We tentatively recommend the use of the PNCIMA proposal, which comprises the best topographical rendering of this objective. However, no boundary fully captured the extent of all watersheds. On the other hand, we note the large terrestrial area of the PNCIMA proposal, even though it does not capture the full extent of the watersheds, may already be so large that it could pose managerial difficulties. As this consideration falls outside of the ecological focus of this report, we will not explore it further, other than to note that DFO should be aware of this conflict between ecological and managerial considerations. We suspect that any "watershed" boundary will have to be a compromise between capturing the major stream reaches, and administrative logistics.

Deep Offshore Large Ocean Management Area

This was not explicitly offered to us as a boundary option. However, after a great deal of discussion, we have decided to include this second recommendation because we feel it offers a strong solution not considered by the other options.

This large offshore LOMA suitably reflects the broad scale of offshore oceanographic processes. We could find no oceanographic process with a variability that did not span the entirety of this offshore region. Thus, we could find no justification in its separation north and south, as suggested by the PNCIMA boundary. In this regard we agree with the principle behind the PIMUPA proposal, which did not extend to the 200 mile limit −though we disagree with the choice of the *top* of the shelf as a break point (see above).

From a practical perspective, this single LOMA would put all BC's seamounts under one management regime. It would also include Endeavour Hydrothermal Vents Marine Protected Area, and the proposed Bowie Seamount MPA. It would allow for comprehensive management of offshore migratory species (mainly mammals) that pass through these waters. Finally, it would allow for dedicated offshore management and research funding.

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