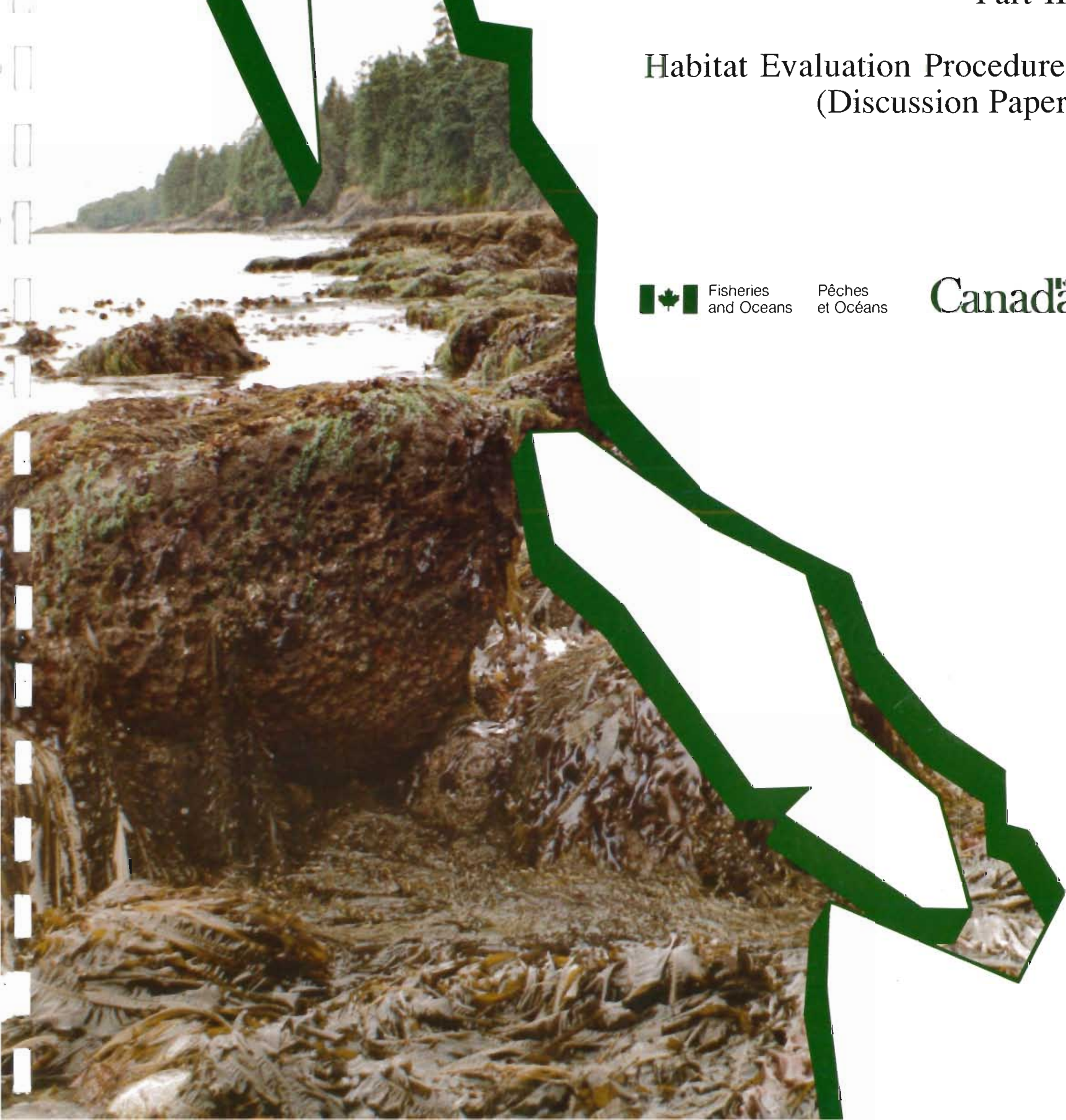
Coastal/Estuarine Fish Habitat Description & Assessment Manual

Part III

Habitat Evaluation Procedures (Discussion Paper)

Fisheries and Oceans   Pêches et Océans   Canada



COASTAL/ESTUARINE FISH HABITAT DESCRIPTION & ASSESSMENT MANUAL

PART III

HABITAT EVALUATION PROCEDURES (DISCUSSION PAPER)

Prepared for

Unsolicited Proposals Program
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PREFACE

In December 1987, G.L. Williams and Associates Ltd. was awarded a contract as a result of an unsolicited proposal to develop a marine foreshore on-site habitat description and assessment evaluation manual for the Department of Fisheries and Oceans (DFO). The unsolicited proposal was funded by the Unsolicited Proposals Program, Department of Supply and Services, Department of Fisheries and Oceans and Environment Canada, Parks. The overall objective of the work was to develop practical, consistent and ecologically based procedures to guide habitat biologists, fisheries officers and other field staff who routinely conduct habitat assessments and evaluations as part of the development project referral process. The work has resulted in four main components: species/habitat outlines for 49 species important to the commercial, sport and Native fisheries, species/habitat references appendix, habitat description procedures manual, and discussion paper on habitat evaluation procedures.

To ensure that the work would be useful to field staff and be scientifically sound, a federal-provincial steering committee was formed to guide the work. The members of the Steering Committee are identified below.

Scientific Authority:	Gordon Ennis Habitat Management Division DFO
Steering Committee:	
Dr. Colin Levings Coastal Habitat Ecology Fisheries Research Branch DFO	Kevin Conlin Fraser River, Northern B.C. Yukon Division DFO
Denis Rowse/Tom Pendray North Coast Division DFO	Bruce Hillaby/Rob Russell South Coast Division DFO
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Dave McBurney Parks Environment Canada	

ACKNOWLEDGEMENTS

The support and comments of the Steering Committee and especially the Scientific Authority, Gordon Ennis, are gratefully acknowledged. I would also like to thank Si Simenstad and Ron Thom, University of Washington, and Dan Bottom, Oregon Department of Fish and Wildlife for useful discussions and/or supplying papers on habitat productivity.

Over the past few years I have become aware of the need for a more ecological or functional approach to habitat evaluations. Of particular influence has been the work in U.S.A. to develop strategies to assess habitats in terms of critical functions. Major influences have been the Wetland Evaluation Technique (WET) (Adamus et al. 1987), and two workshops, Fort Warden I and II, held in the State of Washington; "Wetland functions, rehabilitation and creation in the Pacific Northwest: the state of our understanding" (Strickland 1986) sponsored by the Washington Department of Ecology and "Estuarine wetland restoration protocol, draft report" (Wetland Ecosystem Team, Fisheries Research Institute, University of Washington 1989) sponsored by the U.S. Environmental Protection Agency. The influence of these sessions, and especially the private discussions with several participants, is reflected in this report, which proposes an ecological functions approach to habitat evaluations that would be relatively simple to use and be an extension of Parts I and II of the "Coastal/estuarine habitat description and assessment manual".

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1.0 INTRODUCTION

Assessing the impacts of development proposals on marine and estuarine fish habitat involves several steps including describing existing on-site habitats, identifying fish species (including life stages) and habitats affected, and evaluating impacts so that decisions can be made concerning project approval, mitigation and/or compensation. In Part I, Species/habitat outlines, and Part II, Habitat description procedures, of the Coastal/estuarine habitat description and assessment manual, a systematic and ecological approach for compiling information on the development site and identifying impacts on the species and habitats affected was provided. This volume, Part III, Habitat evaluation procedures, presents an approach for evaluating the impacts on habitat productive capacity.

Evaluating or rating habitat impacts is a difficult activity to undertake, especially in light of the complexity of the ecological interactions involved and the incomplete data base that exists. However, DFO habitat biologists, fisheries officers and managers, in administering the Fisheries Act and specifically the no net loss principle, **must routinely** make decisions related to habitat impacts during the project referral process. In order to develop a more consistent and standardized project review process related to coastal and estuarine project developments for the Pacific Region, fish habitat evaluation procedures are required. Since the topic is sensitive and most evaluation methods are quite controversial, the Steering Committee suggested that the evaluation procedures should be prepared as a discussion paper for intensive internal review by DFO. Following the internal DFO review, the project evaluation procedures will be finalized.

This discussion paper outlines a procedure for evaluating fish habitats after the shore unit habitat description is completed. It attempts to address the need for an improved decision making process (e.g. Dorcey et al. 1978), and at the same time, incorporates a much more ecological or functions approach to habitat utilization. The primary objective of the procedure is to promote a consistent and standardized process for conducting habitat evaluations related to proposed developments. In so doing, habitat biologists and fisheries officers can use the evaluation procedures manual as a guide for determining a rationale for project mitigation and compensation. It will also provide a framework or justification for the DFO decision.

1.1 Definition of Terms

In addressing habitat evaluation it is necessary to define some of the standard terms used. As much as possible, definitions have been adopted from previous work undertaken by DFO. The Fisheries Act provides legal definitions for fish and fish habitat.

(i) fish

> "...includes shellfish, crustaceans, marine animals, and the eggs, spawn, spat and juvenile stages of fish, shellfish, crustaceans and marine animals." (Fisheries Act, sec. 2, incorporation of amendments to January 23, 1989)

(ii) fish habitats

> "Spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes." (Fisheries Act, sec. 34.(1))

The legal definitions of fish and fish habitats show that DFO is legally required to manage a broad range of species and habitats. In managing the fisheries resources in the coastal zone (i.e. marine and estuarine waters) it is important that an ecological perspective be used, one that considers ecological functioning, during assessment of development proposals.

The national fish habitat management policy (DFO 1986) states that there will be no net loss in the productive capacity of habitats to support fish. The critical measure in the policy is productive capacity, which appears to be the equivalent of carrying capacity. Definitions for both terms are shown below.

(iii) productive capacity

> "The maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend." (DFO 1986, p. 30)

(iv) carrying capacity

> "The maximum numbers of an organism that can be supported by a given area or habitat; usually denoted by K; the upper asymptote of the logistical equation (i.e. Verhulst logistical equation $dN/dt=rN[(K-N)/K]$." (Lincoln et al. 1982)

> "...the animal density that can be sustained for a long period of time (Collier et al. 1973)." (Dhondt 1988)

It is important to determine the scientific basis for productive capacity. For example, carrying capacity is based on the logistical growth equation which permits scientific measurement or quantification of the term (in theory at least). Productive capacity may be better described by tolerance or optimum density, which is a population level below carrying capacity (i.e inflection point of the logistical growth equation) that appears to be more appropriate for territorial animals, such as juvenile coho salmon (e.g. see Smith 1974, p. 320-325).

Three other ecological terms are important to consider, including production, productivity and standing stock. The definitions provided by DFO for productivity appear to be more suitable for defining production (i.e. accumulated biomass) rather than productivity (i.e. rate of biomass accumulation).

(v) productivity

"...an index of a habitat's present ability to produce fish, fish food organisms, and detrital matter which are directly or indirectly necessary to support that fish production." (North Fraser Harbour Environmental Management Plan, p. 3)

The measure of the rate of biomass accumulated per unit area per unit time by organisms. (adapted from Proctor et al. 1980, p. GT-13)

"The potential rate of incorporation or generation of energy or organic matter by an individual, population or trophic unit per unit time per unit area or volume; rate of carbon fixation" (Lincoln et al. 1982)

(vi) production

"1. Gross production: the actual rate of incorporation of energy or organic matter by an individual, population or trophic unit per unit area or volume;

2. Net production: that part of assimilated energy converted into biomass through growth and reproduction by an individual, population or trophic unit, per unit time per unit area or volume; that is the balance between assimilation (A) and respiration (R) calculated as $P = A - R$;

3. The biomass, organic matter or energy accumulated by a population or trophic unit plus that lost by elimination (E) [i.e. losses due to mortality, predation, emigration and moulting] per unit time per unit area or volume, calculated as $P = B + E$." (Lincoln et al. 1982)

(vii) standing stock (crop)

The number per unit area or biomass (living weight) per unit area (at any one time). (adapted from Smith 1974, p. 21)

"biomass; the total biomass of organisms comprising all or part of a population or other specified group, or within a given area, measured as a volume, mass (live, dead, dry ash-free) or energy (calories)." (Lincoln et al. 1982)

"Amount of living tissue existing at any given time." (Proctor et al. 1980, p. GT-16)

Note that standing crop may not provide a good indication of the productivity, or productive capacity of a habitat to support fish. For example, low biomass measurements may result from heavy cropping by predation or fishing pressure, or reflect time-limited utilization of a highly productive habitat, and usage of the measurement for its productive capacity could be misleading.

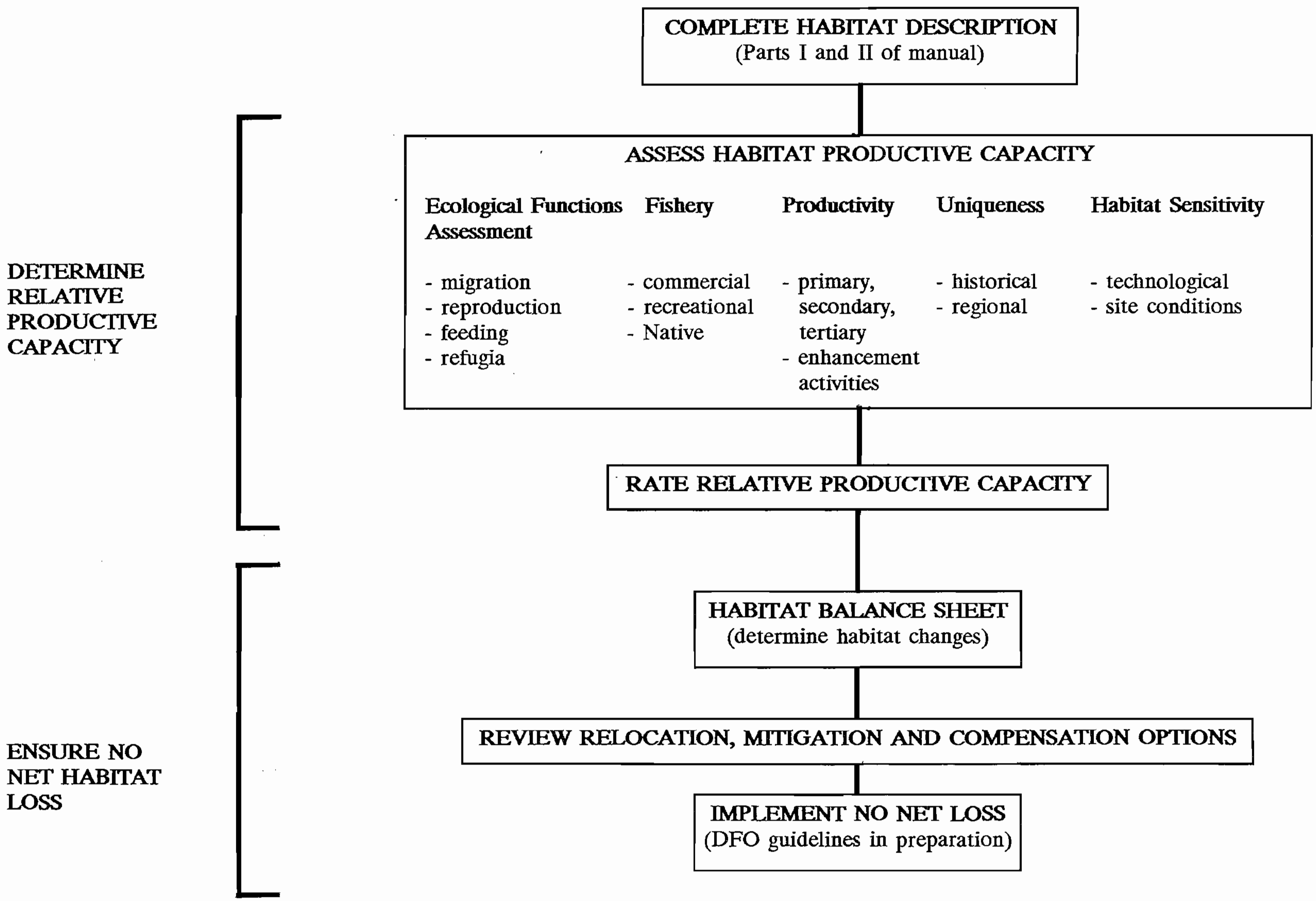
2.0 OVERVIEW OF PROPOSED EVALUATION PROCEDURES

The proposed evaluation procedure consists of two main components (Figure 1). The first involves determining the productive capacity of habitats at the development proposal site, by assessing five key parameters (e.g. ecological functions, fishery, habitat productivity, uniqueness and sensitivity) and rating relative productive capacity. The second component consists of ensuring that there is no net loss in the productive capacity of fish habitats, by determining habitat changes, reviewing relocation, mitigation and compensation options and implementing habitat works in accordance with the DFO guidelines to be released in early 1990.

The evaluation procedure is greatly simplified if the area has been classified or rated by DFO, as is the case for the Fraser River estuary. If the area has been zoned for conservation purposes because of very high productive capacity, or has very high importance for supporting a fishery or social activity, it will not be necessary to re-determine relative productive capacity and the project can be assessed using the DFO no net loss guidelines. In certain circumstances the importance of the area will preclude most, if not all, development.

The first component of the proposed evaluation procedure, determining the relative productive capacity is described in section 3.0. Comments on ensuring no net loss of habitat are briefly discussed in section 4.0.

Figure 1. Proposed DFO project evaluation procedures.



3.0 DETERMINING RELATIVE PRODUCTIVE CAPACITY

3.1 ASSESSING RELATIVE PRODUCTIVE CAPACITY

As has been shown in Part I, Species/Habitat Outlines, a particular fish habitat is the result of many factors including the interaction of physical and biological components, and usually supports several species and ecological functions. To properly evaluate the habitat productive capacity involves consideration of several factors. In developing a standardized DFO procedure for evaluating productive capacity, five parameters are recommended: ecological functions (i.e. species habitat utilization), fishery, habitat productivity, uniqueness and sensitivity. The species/habitat outlines prepared in Part I of the manual illustrated the importance of using an ecological approach to assessing habitat utilization. To assist DFO staff in assessing habitat utilization, an ecological functions assessment procedure (EFA) is proposed. The five parameters are discussed in the following sections.

3.1.1 Ecological Functions Assessment (EFA)

The EFA involves determining species functions for habitats occurring at the proposed development site. Four primary ecological functions that cover the main stages of a species life cycle have been identified : migration, reproduction, feeding and refugia. To account for specialized features of a function for a particular species, each function has two or more categories. The functions have been selected to account for critical behavioral activities in the life cycle and attempt to address habitat utilization and use of the water column.

The following life history functions were identified for evaluating species habitat utilization:

(1) migration - including active migration, passive migration and staging or holding prior to active migration

(2) reproduction - including mating/breeding and spawning

(3) feeding - including nursery and rearing areas for juveniles, adult feeding locations and indirect food support (i.e. production and export)

(4) refugia - including areas used for protection from predators and competition

Migration has three modifiers: staging, active and passive. Staging refers to a pre-migratory phase that many species exhibit. For example, salmon may hold at the mouth of a spawning stream waiting for higher discharge or physiological changes prior to migrating upstream to spawn. Herring may hold in nearshore bays to complete maturation prior to spawning. Active migration refers to a definite, deliberate movement to undertake some activity (e.g. salmon spawning migration). Passive refers to a movement of organisms into an area which is not deliberate (e.g. entrainment of invertebrate and fish larvae into an eelgrass bed). Migration may occur in a particular habitat for a very short period of time, and only involve fish or invertebrate passage through an area. However, the presence of the water column (i.e. living space) is important for the migration function, and physical or chemical alteration of the water column may affect migratory patterns, thereby reducing productive capacity as well as the population.

Reproduction includes mating and spawning, which for some species can occur in different habitat types at different times. For example, Dungeness crabs may mate inshore during the summer but females move to deeper water to hatch the eggs in late winter.

Feeding includes nursery, rearing, adult and export modifiers. Aquatic habitats may provide nursery areas for invertebrate or fish larvae, or may be adjacent to a spawning stream and provide feeding areas for very small (young) fish. Rearing areas are used by juvenile organisms which often support the feeding function of fish and invertebrates that have migrated into the area. Rearing implies some residence time (e.g. chinook rear in tidal channels for up to several months). The adult feeding function refers to adult feeding grounds (e.g. adult cutthroat trout make intensive use of inshore habitats for feeding). Export refers to indirect trophic associations not covered by the three other modifiers. For example, *Salicornia* detritus was the most important detritus tested for Pacific oyster survival and of moderate importance for blue mussel (Hoffnagle 1976 cited in Seliskar and Gallagher 1983). For Pacific oyster, salt marsh could be recorded as a habitat supporting the feeding, export function.

Refugia refers to use of a particular area for protection from predation or physiological adaptation for a subsequent stage in the species life cycle. For example, schooling and use of eelgrass beds by chum fry and use of turbid (i.e. estuarine) water by chinook smolts may be behavioral adaptations to avoid predation. Juvenile salmon may rear in tidal channels in marshes to complete the smoltification process and possibly enhance ocean survival, illustrating an example of refugia for physiological function.

Example EFA:

To illustrate the basic procedure for preparing an EFA, a hypothetical marina development is used. The development proposal is located in a marine bay on Vancouver Island and only the intertidal and subtidal zones are of concern. The habitat description abbreviations are identical to those used in the shore unit habitat classification (Part II of the manual):

intertidal: (i) upper gravel, sand beach - **I:Bgs**, or **B:gs:A** if macroalgae are present

(ii) bedrock platform with boulders - **I:Pb**, or **I:Pb:A** if macroalgae are present

shallow subtidal: (i) eelgrass - **Ss:E**

As well the general water column habitat is also identified and coded as **W.**

Based on the information and data compiled for the project site, 20 of the 49 species covered in the species/habitat outlines (Part I of the manual) are known to occur in the marine bay. One, (i.e. octopus) is considered to utilize deep subtidal areas only, so it is excluded.

The species list and habitats utilized for each function are shown in the EFA (Table 1). The EFA can be completed using the species/habitat outlines (Part I of the manual) or species/habitat matrix (Part II of the manual), or using site specific knowledge based on personal observations, sampling data or fisheries harvest information.

The overall results of the EFA show that eelgrass and water column are the most important habitats supporting species utilization in the bay. Although water column has a relatively high total, it is primarily restricted to the migration function and will not be seriously disrupted by the development proposal. Excluding water column, the most utilized habitats in descending order of utilization are eelgrass (49%), intertidal beach (25%), intertidal algae (20%) and intertidal platform (5%). Eelgrass habitat supports about twice the relative functions as sand gravel beach and almost 2.5 times that for intertidal macroalgae. Further, the EFA demonstrates that some organisms, such as bivalves, are dependant on substrate independent of vegetation cover, while other species such as fish and are more dependent on vegetation, especially during juvenile stages.

Another version of a EFA is shown in Table 2, in which target species have been selected. The target species were selected according to relative importance (e.g. in terms of abundance, the fishery, unique characteristics, etc.) and an attempt was made to include fishes and invertebrates. For example, chum have been captured at the site during DFO beach seining and cutthroat are considered by MOE to be a unique genetic population. Surf smelt are known to spawn in the bay and are harvested by the Natives. Littleneck clam, cockle, and Dungeness crab are harvested by the Indian band and were observed at the site.

Although the totals obviously are different from Table 1, the importance of eelgrass is again demonstrated.

Table 1. Ecological functions assessment for species known to utilize habitats in a hypothetical marine bay.

Species	Migration			Reproduction		Feeding			Refuge	
	staging	active	passive	mating	spawning	nursery	rearing	adult	predation	transition
chum salmon			W				I:Bgs I:A Ss:E		I:Bgs I:A Ss:E	
coho salmon		W					Ss:E			
pink salmon			W				W I:Bgs I:A Ss:E		Ss:E	
cutthroat trout	W	W					I:Bgs I:A Ss:E	I:Bgs I:A Ss:E	I:Bgs I:A Ss:E	
steelhead trout							I:Bgs I:A Ss:E			
copper rockfish			W				Ss:E		Ss:E	
surf smelt		W			I:Bgs	W	W Ss:E		Ss:E	
Pacific herring			W				W Ss:E		Ss:E	

Table 1. (continued).

Species	Migration			Reproduction		Feeding			Refuge	
	staging	active	passive	mating	spawning	nursery	rearing	adult	predation	transition
starry flounder							Ss:E		Ss:E	
butter clam			W		I:Bgs					
littleneck clam			W		I:Bgs					
cockle			W		I:Bgs Ss:E					
soft-shell clam			W		I:Bgs					
Pacific oyster			W		I:Bgs I:Pb					
blue mussel			W		I:Bgs Ss:E					
geoduck			W		Ss:E					
sea cucumber								Ss:E		
Dungeness crab			W	Ss:E			I:A Ss:E	Ss:E	I:A Ss:E	

Table 1. (continued).

Species	Migration			Reproduction		Feeding			Refuge	
	staging	active	passive	mating	spawning	nursery	rearing	adult	predation	transition
red rock crab			W	Ss:E			I:A I:Pb Ss:E	Ss:E	I:A Ss:E	
Subtotals	1W	3W	13W	1Ss:E	6I:Bgs 2I:Pb 3Ss:E	1W	3W 5I:Bgs 6I:A 1I:Pb 11Ss:E	1I:Bgs 1I:A 3Ss:E	2I:Bgs 4I:A 9Ss:E	
Totals[a]	1	3	13	1	11	1	26	5	15	

[a] totals are:

water column =	21
I:Bgs =	14
I:A =	11
I:Pb =	3
Ss:E =	27
	76

Table 2. Ecological functions assessment for target species known to utilize habitats in a hypothetical marine bay.

Species	Migration			Reproduction		Feeding			Refuge	
	staging	active	passive	mating	spawning	nursery	rearing	adult	predation	transition
chum salmon			W				I:Bgs I:A Ss:E		I:Bgs I:A Ss:E	
cutthroat trout	W	W					I:Bgs I:A Ss:E	I:Bgs I:A Ss:E	I:Bgs I:A Ss:E	
surf smelt		W			I:Bgs	W	W Ss:E		Ss:E	
littleneck clam			W		I:Bgs					
cockle			W		I:Bgs Ss:E					
Dungeness crab			W	Ss:E			I:A Ss:E	Ss:E	I:A Ss:E	
Subtotals	1W	3W	13W	1Ss:E	6I:Bgs 2I:Pb 3Ss:E	1W	3W 5I:Bgs 6I:A 1I:Pb 11Ss:E	1I:Bgs 1I:A 3Ss:E	2I:Bgs 4I:A 9Ss:E	

Table 2. (Continued).

Species	Migration			Reproduction		Feeding			Refuge	
	staging	active	passive	mating	spawning	nursery	rearing	adult	predation	transition
Totals[a]	1	3	13	1	11	1	26	5	15	

[a] total W = 8 (20.5 %)
total I:A = 8 (20.5 %)
total I:Bgs = 8 (20.5 %)
total Ss:E = 15 (38.5 %)

Total = 39 (100 %)

And ratio is W : I:A : I:Bgs : SsE = 1 : 1 : 1 : 2.

3.1.2 Fishery

The fishery is assessed by evaluating commercial, sport, and Native fisheries data. Commercial fisheries statistics produced by DFO can be useful in evaluating the importance of the site to commercial fishing on a larger spatial context. Recreational and Native fisheries are also important factors to consider, and usually are more site specific than commercial statistics.

The commercial fisheries statistics for hypothetical statistical area 109 and the South Coast Division are shown in Table 3. As can be seen from Table 3, area 109 accounts for less than one per cent of the total landings and landed value for the South Coast Division. However, the area 109 catch exceeds the average South Coast Division catch and value (i.e. the total South Coast catch divided by 17) for three species: octopus, sea cucumber, and crab. Dungeness and red rock crab are present in the study area but only Dungeness crab is taken in the commercial fishery. Therefore, the habitats that Dungeness crab utilizes can be considered as being especially valuable.

The bay in which the proposed project is sited, also supports an intensive Native fishing area. Organisms harvested include clams, oysters, crab, smelt, salmon, trout and octopus. The Native band depends on these fisheries for food, and harvesting activities are considered by the band to be part of their cultural heritage.

The site supports a beach sport fishery (i.e. fly fishing) for salmonids. The main species taken include cutthroat trout and steelhead. The cutthroat trout are a unique genetic population, being larger fish compared to other nearby stocks. The stream that enters the bay just south of the proposed project site is used for spawning. For several years enhancement activities have been undertaken to increase the cutthroat population. The Native band is also undertaking stream enhancement for coho.

Fishery data can also be used to determine trends in catch. For example, if the catch is showing a downward trend, more habitat conservation may be warranted for selected species to increase stocks. This should be determined in consultation with area management biologists or scientists from the Pacific Biological Station. Caution should be used in interpreting trends because higher stocks or catch may be the result of other factors such as enhancement activities.

Table 3. 1986 commercial catch statistics for South Coast District and Statistical Area 109.

Species	South Coast District		Statistical Area 109	
	landings (tonnes)	landed value ($000)	landings (tonnes)	landed value ($000)
chinook	2 308	10 270	*	*
sockeye	17 607	84 690	*	*
coho	6 202	8 187	*	*
pink	1 299	1 494		
chum	11 765	17 765		
steelhead	10	18		
subtotal	**39 191**	**122 416**		
herring	688	1 679		
herring (kelp spawn)	17	722		
lingcod	2 352	1 858	33	34
rockfish	11 440	7 207	25	16
subtotal	**14 497**	**11 466**	**58**	**50**
clams	2 706	3 599	5	7
geoduck	3 302	2 840	124	107
oysters	2 864	2 520		
octopus	45	116	11	28
sea cucumbers	786	236	163	49
shrimp	593	954	1	2
prawns	388	2 635	12	81
crab	681	2 921	98	420
subtotal	**11 365**	**15 821**	**414**	**694**
TOTAL	**65 053**	**149 703**	**472**	**744**

* less than 100 kg

3.1.3 Productivity

Nearshore habitats are used intensively by numerous species of invertebrates and fish for feeding, reproduction and refuge. Detritus is a major component of trophic ecology and knowledge of primary productivity for habitats under study can be useful in evaluations. Primary productivity values for selected habitats are given in Table A-1, Appendix A. Review of the scientific literature indicated that there is considerably less data for secondary and tertiary production (Appendix A, Tables A-2 and A-3, respectively).

Assessment of productivity may also include review of enhancement activities. Productivity of habitats can be increased through enhancement activities and development proposals could detrimentally affect the success of the enhancement measures.

3.1.4 Uniqueness

Assessing uniqueness involves subjective, regional and historical analysis. By including the surrounding area with the immediate project site, it is possible to include consideration of the cumulative impacts in the larger geographic area. For example, is the area pristine or are there other developments? If pristine, permitting marina development would destroy this unique setting and reduce the productive capacity of the bay. The bay supports important ecological functions for several species. It also supports a genetically unique cutthroat population, has a Native fishery and includes very productive eelgrass habitat that is used intensively by important commercial fisheries species such as Dungeness crab, pink and chum salmon.

3.1.5 Sensitivity

Habitats have varying degrees of sensitivity to development. The sensitivity can be attributed to several factors including chemical and physical factors. Many of the more productive habitats occur in sheltered areas where finer substrates accumulate and vegetation can develop. Others, such as eelgrass, need relatively clear water and excessive turbidity can reduce light penetration into the water column and inhibit growth. Surfgrass requires rocky substrate in high wave energy areas. Poorly flushed areas may also collect pollutants such as oil and grease that could reduce the productive capacity of vegetated habitats. Therefore, to ensure that there is no net loss in productive capacity, habitat sensitivity to development should be assessed.

Habitats sensitivity may also be assessed in terms of compensation potential. Generally compensation techniques such as marsh or eelgrass bed creation are quite well established from a technological perspective, but the reliability in terms of probability of success is much more advanced with marsh than eelgrass transplants.

Some marine environments are more exposed than others with active coastal processes making certain types of habitat compensation more difficult. This type of habitat sensitivity should also be assessed as part of the project evaluation process.

3.2 RATING RELATIVE PRODUCTIVE CAPACITY

Once the ecological functions assessment has been completed and the fishery, habitat productivity, uniqueness and sensitivity have been assessed, the relative productive capacity of the proposed development site is rated. The rating scheme consists of four levels; very high, high, moderate and low, with each level given a numerical value of 4, 3, 2 or 1, respectively. To provide flexibility for uncertainty, half values can also be use. The relative productive capacity rating is the sum of the rating for ecological functioning, productivity, fishery, uniqueness and sensitivity assigned values. The overall relative productive capacity ratings are:

- very high	above 17.5
- high	12.5 to 17.5
- moderate	7.5 to 12.5
- low	under 7.5

For areas where habitats have been zoned for conservation or sanctuary status or have been officially classified according to relative productivity (i.e. Fraser River estuary), the relative productive capacity rating is not required and the evaluation procedure is very much simplified.

Rating the relative productive capacity of habitats at a proposed development site will assist decision making. For example, for habitats with very high productive capacity the proposal will not be permitted if there is a loss of habitat and it will have to be relocated. To assist DFO staff in making decisions related to development proposals, hierarchical preference guidelines have been identified in the national habitat policy and will be refined further in official DFO guidelines to be released in 1990.

The rating criteria are briefly discussed below.

1. EFA

Based on the EFA, a site can be rated as having very high productive capacity in terms of species diversity and amount of habitat utilization. Sites supporting many functions (i.e. migration, reproduction, feeding and refugia) for several species or very intensive utilization may be rated very high. Areas of repeated heavy herring spawning, intensively utilized estuarine marshes, oyster spawning areas (e.g. Pendrell Sound) used to supply spat for planting in other areas are examples of areas which would be rated very high. Supporting data could include specific knowledge (e.g. Fisheries Officers, Research Scientists, local citizens, etc.), scientific literature or the ecological functions assessment. As noted above, a rating of 1, 2, 3 or 4 may assigned to a site's EFA.

2. Productivity

Primary productivity values from Table A-1 can be used to rate productivity. If data are not available, a subjective rating can be assigned based on other site specific data, such as standing crop measurements (e.g. abundance of benthic salmonid food organisms or abundance of juvenile salmonids, bivalves or other organisms of interest). As noted above, a rating of 1, 2, 3 or 4 may assigned to a site's productivity.

3. Fishery

Areas which directly or indirectly support fisheries are also rated. Fisheries include all commercial, recreational and Native harvesting, as well as enhancement activities. All fisheries are included regardless of size. For example, a fishery may be comparatively small in total landing but may have important localized impacts or social value. As noted above, a rating of 1, 2, 3 or 4 may assigned to a site's fishery.

4. Uniqueness

Habitats which support endangered, rare or threatened species, including those targeted for conservation, unique or special species or genetic stocks, species functions that form part of a productive ecological unit, and those that are scarce in the ecological unit or surrounding area, are examples of areas rated as having high uniqueness. As noted above, a rating of 1, 2, 3 or 4 may assigned to a site's uniqueness.

5. Habitat Sensitivity

Habitats with very high sensitivity to development include highly utilized and/or productive areas with poor flushing or which would be severely affected by development. As well habitats resulting from specific environmental conditions which are locally unique may receive high ratings. This includes consideration of compensation potential. As noted above, a rating of 1, 2, 3 or 4 may assigned to a site's habitat sensitivity.

Application Example

Based on Table 1 the ecological functions at the hypothetical marine bay study site has been rated as being high, moderate or low for the main functions.

1. EFA

Migration: Moderate

Rationale

- small numbers of adult coho and cutthroat migrate to creek to spawn, and juveniles out-migrate

- Dungeness crab movements related to reproduction function

Reproduction: High

Rationale
- surf smelt spawn on gravel, sand beach
- cockle, littleneck clam and geoduck spawn in project site (i.e. sand beach and eelgrass beds)
- sea cucumber may spawn in eelgrass

Feeding: High

Rationale
- nursery area for surf smelt and Dungeness crab
- juvenile feeding for salmonids, surf smelt, Pacific herring, Dungeness crab and sea cucumber
- adult feeding for cutthroat, Dungeness crab, and sea cucumber

Refugia: High

Rationale
- refuge for juvenile salmon, surf smelt, Pacific herring, Dungeness crab and sea cucumber

Net EFA value = 3.

2. Fishery

The fishery has been summarized based on catch statistics information (see Table 3).

	Commercial	Recreational	Native
catch value	Low	High	High
catch volume	Low	Low	High

Notes: - Dungeness crab and sea cucumber contributions in Statistical area 109 are above average for South Coast
- valued beach sport fishery
- cutthroat (fry plants) and coho enhancement has been undertaken by Ministry of Environment and Indian band

Net fishery value = 2.

3. Productivity:

No habitat productivity data are available for the study site. However, based on the fact that the bay contains dense eelgrass beds and supports a diverse assemblage of aquatic organisms, the site is assigned a high rating.

Net productivity value = 3.

4. Uniqueness:

The marine bay in which the marina development is located is the last undeveloped, protected, natural bay in the surrounding peninsula. It also supports a small, but genetically unique population of cutthroat trout.

Net uniqueness value = 4.

5. Sensitivity:

The habitats found at the site are considered sensitive because there does not appear to be suitable compensation sites within the bay and the impacts of the marina should development be permitted could be detrimental to the remaining habitats. It would also reduce the harvest area for the native fishery and could have detrimental impacts on a unique genetic stock of cutthroat trout. Therefore the site is assigned a high rating.

Net sensitivity value = 3.

The rating for the relative productive capacity for the proposed site is:

EFA:	high	= 3
Fishery:	moderate	= 2
Productivity:	high	= 3
Uniqueness:	very high	= 4
Sensitivity:	high	= 3
Total	high	= 15

The relative productive capacity for the proposed development site is 15, indicating it has a high productive capacity. Therefore, when applying the DFO no net loss guidelines efforts should be made to relocate and mitigate the proposal. If relocation cannot take place, any residual impacts must be offset by the creation of like compensation habitat at or near the development site.

4.0 COMMENTS ON EVALUATING DEVELOPMENT PROPOSALS

As has been mentioned previously, DFO is developing in-house guidelines for applying the no net loss principle. In an attempt to standardize the evaluation of development project proposals, steps are outlined below that would promote more consistent project reviews. The standardization of the process is complicated by the fact that the procedure most be flexible to account for site specific conditions (i.e. habitat, species, type of project and impacts, amount of existing data, and management information). The comments provided below pertain to the evaluation procedure once the habitat has been rated (i.e. using the procedure described in section 3 or based on existing DFO conservation zoning).

Proposed steps for evaluating development proposals are:

1. prepare habitat balance sheet and determine habitat losses and functions

2. review relocation, mitigation and compensation options

3. formulate decision using official DFO guidelines (in press)

4.1 PREPARE HABITAT BALANCE SHEET

Usually, it is necessary to determine habitat changes by preparing a habitat balance sheet. A hypothetical balance sheet has been prepared for a proposed marina development (Table 4). As the habitat balance sheet shows, there is a loss in area of eelgrass habitat. Some water column is created but it is largely due to dredging the marina basin and much of the created water column is deep subtidal, which has limited support for juvenile rearing, etc. Other habitat types, appear to be compensated by the creation of macroalgae habitat (i.e. rock rip rap breakwater). Although the areal losses of intertidal habitats appear to be replaced, it should be noted that the intertidal beach, which supports several species of bivalves, will be destroyed. Given the high productive capacity and Native harvest, the habitat loss would not be acceptable unless the loss can be replaced on-site. The EFA showed that eelgrass was extremely important, supporting almost 50% of the species function, it is important that eelgrass be compensated if the no net loss guideline is to be met.

4.2 REVIEW RELOCATION, MITIGATION AND COMPENSATION OPTIONS

Review of the project would include assessment of relocation or alternate siting, mitigation, and compensation options.

1. Relocation (Alternative Siting)

Examination of relocation opportunities of a development project will be requested if it has detrimental impacts on very high or high productive habitat or in areas zoned

Table 4. Hypothetical habitat balance sheet for a proposed marina development. (All figures represent number of m^2, unless indicated otherwise).

Habitat Type	destroyed	created	net
1. water column			
area	- 10,000	0	- 10,000
volume (m^3)	- 40,000	+ 55,000	+15,000
2. intertidal habitat			
sand, gravel beach	- 8,000	0	- 8,000
intertidal macroalgae	- 5,000	+ 10,000	+ 5,000
intertidal bedrock	- 2,000	0	- 2,000
3. subtidal habitat			
eelgrass	- 28,000	0	- 28,000

conservation. For example, siting development proposals in areas of very high productive habitat such as heavy herring spawning habitat must not be permitted and the project relocated or rejected. In high productive habitats relocation should also be considered. In areas of lesser productivity, relocation should also be considered, depending on specific conditions of the site. A proposal to locate a jet fuel barge off-loading facility on Sea Island in the Fraser River estuary was considered unacceptable by DFO due to spill risks to very important fish stocks.

The relocation investigation should include consideration of the following factors: need, water-dependency, the availability of suitable alternative sites, proponent ownership and the public desires. The outcome of the investigation should be an agreement with the proponent as to whether the proposal is to be relocated or not. If agreement cannot be reached the matter should be referred to more senior staff.

In some instances a development proposal may be located in a preferred location which preserves adjacent higher productive areas. For example, siting a barge facility or a marina in a marine bay may preserve more intensively utilized estuarine rearing habitat, or it may be possible to site a project in a moderately or highly productive area if impacts are avoided and the ecological functions are not detrimentally affected. For example, a piling supported pier may be constructed in deeper water in front of a marsh and still permit juvenile salmon rearing in the marsh. In fact, the presence of the pier may provide some protection from erosion caused by boat waves.

2. Mitigation Options

Mitigation options include, but are not confined to, the following:

1. minimizing impacts through design alterations

   - shift project components to less sensitive locations within project site (e.g. relocate parking lots to upland from intertidal areas, site instream facilities in deeper water to avoid impacting shallow water habitats or disrupting functions and avoid subsequent impacts (e.g. avoid dredging intertidal), promote flushing in enclosed basins (e.g. marinas))

2. scheduling activities to avoid impacting species and/or functions

   - avoid instream construction during migration, spawning, rearing, etc.

3. implementing measures to control impacts

   - select construction techniques that minimize impacts (e.g. use pilings instead of intertidal fills, commence dredging from blind end of closed estuarine sloughs to avoid trapping juvenile salmon, use siltation control measures on upland construction to avoid silting nearshore habitats)

- operate facility in environmentally sound manner (e.g. control toxic materials such as fuel, install pump out facilities, supply proper code of use for users, keep facilities well maintained)

4. incorporating habitat into facilities

   - create intertidal benches, gentle slopes and irregular edges in shoreline protection and breakwaters, use native riparian vegetation in landscaping, creation of reefs in deeper water

3. Compensation

Compensation measure considerations include, but are not confined to, the following.

1. type of compensation

   For high productive habitats, like compensation on-site is the only acceptable compensation. Other compensation options may be considered for lower productivity habitats including options such as: like habitat off-site, unlike and higher productive capacity habitat on-site or off-site. In certain limited circumstances artificial propagation can be considered. As one descends the hierarchy of preferences the risk to the resource increases and all effort should be made to carry out compensation on-site on a like-for-like basis. These options are described in the DFO guidelines.

2. probability of success in implementing no net loss

   Generally, reliable habitat compensation techniques are available to construct habitats. While it may be technically feasible to create habitat, the end results may not adequately replace existing habitats in terms of productive capacity (e.g. ecological functions such as migration, reproduction, feeding and refugia). Evaluating the probability of success involves consideration of the environmental factors that determine the productivity of the existing habitat versus those at the compensation site. For example, the physical conditions at the compensation site may require continual maintenance or substantial (and expensive) engineering structures to maintain the stability of the site. Generally there has been more demonstrated success in creating marshes than eelgrass beds, but it is not yet clear if no net loss at the site has been achieved.

3. administrative and security considerations

Compensation sites must be constructed in locations that are acceptable to agencies with jurisdiction over the area. For example, constructing habitats in a navigational channel may not be acceptable because it may restrict future development options. It is important to ensure that the compensation works themselves do not create problems for other resource agencies such as the Canadian Wildlife Service. For this reason, DFO should ensure that proponents compensation plans meet with approval from other agencies as well.

4.3 FORMULATE DECISION USING DFO GUIDELINES (IN PRESS)

DFO is preparing procedures for the guidance of DFO staff in the application of no net loss and the official guidelines, in combination with this coastal/estuarine manual, should improve the quality of decision making.

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APPENDIX A - PRODUCTIVITY DATA

Table A-1. Productivity ($gC.m^{-2}.y^{-1}$) or standing crop (gm dry weight.m^{-2}) values for selected species and habitats found in British Columbia nearshore waters.

Location	Species or Habitat	Productivity or (standing crop)	Source
Water column:			
Nanaimo estuary	phytoplankton	7.5	Naiman & Sibert (1979)
	phytoplankton	12.1	Naiman & Sibert (1978)
Strait of Georgia	phytoplankton	120	Parsons et al. (1970)
Roberts Bank	phytoplankton	58	Levings unpubl. data (1980) cited in Truscott (1981)
Hood Canal, WA	phytoplankton	229	Simenstad & Wismarr (1985)
Nova Scotia	phytoplankton	191	Mann 1973
Sand/mud:			
Nanaimo estuary	sediment detritus	58-233	Naiman & Sibert (1979)
	benthic microalgae	4-55	
	benthic microalgae	22.5	Naiman & Sibert (1978)
Hood Canal, WA	benthic microalgae	143-266	Simenstad & Wissmar (1985)
Squamish estuary	benthic algae	215	Pomeroy & Stockner 1976
Rock/gravel:			
Squamish estuary	benthic algae	215	Pomeroy & Stockner 1976
Nanaimo estuary	macroalgae	0.9-7.5	Naiman & Sibert (1979)
	macroalgae	0.9	Naiman & Sibert (1978)

Table A-1. (continued).

Location	Species or Habitat	Productivity or (standing crop)	Source
Hood Canal, WA	*Ulva/Enteromorpha*	4644	Simenstad & Wissmar (1985)
Nova Scotia	*Fucus*	640-840	Mann (1973)
Nova Scotia	*Laminaria*	1200-2000	Mann (1973) cited in Show (1982)
B.C.	*Iridea cordata*	2070[c]	Waaland (1976) cited in Show (1982)
Dundas Archipelago	*Macrocystis* & *Nereocystis*	(267-299)[c]	Coon (1982)
Barkley Sound	*Macrocystis integrifolia*	250 (foliar) 1300 (forest)	Wheeler & Druehl (1986)
Eelgrass:			
Nanaimo estuary	*Zostera marina*	27	Naiman & Sibert (1979)
	Zostera	50-150	Naiman & Sibert (1978)
	Z. marina	73	Healey (1982)
Fraser estuary	*Z. marina*	(4-88)[b]	Moody (1978a), Harrison (1982) cited in Phillips (1984)
Roberts Bank	*Z. marina*	118	Harrison pers. comm. (1981) cited in Truscott (1981)
	Z. epiphytes	(13)	data cited in Truscott (1981)
Hood Canal, WA	*Z.* meadow	20-165	Simenstad & Wissmar (1985)
	Z. epiphytes	1-8	

Table A-1. (continued).

Location	Species or Habitat	Productivity or (standing crop)	Source
Boundary Bay	*Z. japonica*	(4-20)[b]	Harrison (1982) cited in Phillips (1984)
Marsh, salt:			
Fraser estuary	*Salicornia*	129a	Yamanaka (1975) cited in Habitat Work Group (1978)
	Elymus/Poa	178[a]	
	Triglochin/Elymus	50[a]	
	Atriplex	343[a]	
Nanoose - Bonnel estuary	*Salicornia*	423a	Dawe & White (1986)
	Carex - edge	566[a]	
	Carex/Distichlis	449[a]	
	Juncus	342[a]	
Hood Canal, WA	*Carex*	529	Simenstad & Wissmar (1985)
	Juncus/Potentilla	956-1108	
Nisqually estuary, WA	*Festula/Carex*	489[a]	Burg et al. (1980)
	Carex	626[a]	
	Salicornia	329[a]	
	Distichlis/Salicornia	428[a]	
	Carex/Distichlis	409[a]	

Table A-1. (continued).

Location	Species or Habitat	Productivity or (standing crop)	Source
Marsh, brackish:			
Nanaimo estuary	*Carex*	495	Naiman & Sibert (1978)
	Carex	564	Naiman & Sibert (1979)
Squamish estuary	*Carex*	595[a]	Levings & Moody (1976)
Little Qualicum estuary	*Carex* - edge	683[a]	Dawe & White (1982)
	Deschampsia	405[a]	
	Juncus	345[a]	
Fraser estuary estuary	*Typha*	200[a]	Yamanaka (1975) cited in Habitat Work Group (1978)
	Carex	459-747a	
	Scirpus validus	140[a]	
	S. maritimus	226[a]	
	S. maritimus - *S. americanus*	220[a]	
	S. americanus	203[a]	
Fraser estuary	*Carex*	409[a]	Moody (1978)
Fraser estuary	*Carex*	285a	Kistritz et al. (1983)
Nehalem Bay, OR	*Triglochin*	104[a]	Eilers (1979)
	Aster/Potentilla	1260[a]	
	Carex	1170[a]	

Table A-1. (continued).

Location	Species or Habitat	Productivity or (standing crop)	Source
Marsh, riparian:			
Fraser estuary	*Phalaris*	448[a]	Barnard (1975) cited in Habitat Work Group (1978)
	Spirea	863[a]	
	Typha	484[a]	
	S. microcarpus	494[a]	
	S. acutus	145[a]	
	Calamagrotis	502[a]	

a dry weight was converted to gC by multiplying by 0.45 (Seliskar and Gallagher 1983; Zieman and Wetzel 1980)

b biomass: includes whole plant (g dry wt.m^{-2})

c standing crop (wet wt.m^{-2}) was converted to dry wt (i.e. multiply by 0.12) and converted to gC (i.e. multiply by 0.53, Zieman and Wetzel 1980)

Table A-2. Secondary productivity (g wet weight.$m^{-2}.y^{-1}$) or annual production values (g wet weight.$m^{-2}.y^{-1}$) for selected species and habitats found in British Columbia waters.

Location	Species	Habitat	Productivity	Production	Source
Squamish estuary	*Eogammarus confervicolus*	*Carex* bank		21.38-21.65	Stanhope and Levings (1985)
		Fucus		11.31-12.99	
		wood debris		6.12- 6.75	
	Gnorimosphaeroma oregonesis	*Carex* bank		26.77	
		Fucus		3.87	
		wood debris		13.46	
	Corophium spinicorne	*Fucus*		4.66	Stanhope (1983)
		wood debris		0.78	
		mud		12	
Nanaimo estuary	*Harpacticus uniremis*	combined	0.15-0.87		Sibert (1979)
			0.71-3.08		
	all harpacticoids	combined	5.8		

Table A-2. (Continued).

Location	Species	Habitat	Productivity	Production	Source
San Francisco Bay, CA	combined infauna	mudflat	53-100 AFDW		Nichols (1977)

Table A-3. Tertiary (fish) production (g wt weight.m^{-2}.y^{-1}) values for selected species and habitats found in British Columbia waters.

Location	Species	Habitat	Production	Source
Nanaimo estuary	chum fry	combined	0.11-0.37	Healey (1979)
	chum fry	combined	0.152	Healey (1982)
	juvenile chinook	combined	0.017	
	juvenile coho	combined	0.004	
	total of three	combined	0.174*	
Nitinat estuary	chum fry	combined	0.010	
	juvenile chinook	combined	0.027	
	juvenile coho	combined	0.005	
	juvenile sockeye	combined	0.0002	
	total of four	combined	0.041	
South Slough, OR	combined	tideflat	3.28	Bottom (1988)
		tidal channel	11.94	
	surf smelt	tideflat	0.11	
		tidal channel	0.01	
	starry flounder	tideflat	0.11	
		tide channel	0.08	
	English sole	tideflat	0.04	
		tidal channel	0.25	
	Pacific herrring	tideflat	0.03	
		tidal channel	0.03	
	chinook fry	tideflat	0.01	
		tidal channel	0.08	

* total production divided by area of estuary based on figures supplied in paper