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PROFILE

No Net Loss of Fish Habitat: A Review and Analysis of Habitat Compensation in Canada

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ABSTRACT / The achievement of No Net Loss (NNL) through habitat compensation has rarely been assessed in Canada. Files relating to 124 *Fisheries Act* Section 35(2) authorizations issued by Fisheries and Oceans Canada for the harmful alteration, disruption, and destruction of fish habitat (HADD) were collected and reviewed. Data extracted from these files were pooled and analyzed to provide an indication of the types of HADDs that have been authorized in Canada, what habitats have been affected, and what habitat management approaches have been used when compensating for HADDs and monitoring and ensuring the success of the compensation. Determinations regarding the effectiveness of habitat compensation in achieving NNL were made. Impacts to 419,562 m^2 of fish habitat from the 124 authorized HADDs were offset by 1,020,388 m^2 of compensatory habitat. Eighty percent of the authorizations had compensation ratios (compensation area:HADD area) of 2:1 or less, and 25% of the authorizations had a compensation ratio that was less than 1:1. In-channel and riparian habitat were the most frequently impacted habitats. Urban development and roads and highways resulted in the greatest areal loss of habitat. The compensation option that was most often selected was the creation of in-kind habitat. The mean duration of post-construction monitoring programs was 3.7 years. Determinations of NNL could only be made for 17 authorizations as a result of poor proponent compliance with monitoring requirements and the qualitative assessment procedures used by the monitoring programs. Adequate resources, proper training, and standardized approaches to data management and monitoring programs are required to ensure that the conservation goal of NNL can be achieved in Canada.

The no net loss (NNL) principle has been the cornerstone of habitat conservation policies both in Canada and the United States for more than a decade (DFO 1986, USEPA/USACE 1990). In the United States, the Army Corps of Engineers (USACE) applies the NNL principle when it issues permits for the discharge of dredged or fill material into wetlands under Section 404 of the *Clean Water Act* (USEPA/USACE 1990). In applying the principle, USACE attaches conditions to Section 404 permits that require the proponent to compensate for environmental damage and losses of habitat from the dredging and filling of wetlands through wetland creation, restoration, enhancement, or preservation to ensure an overall NNL of wetlands by acreage and function (Kruczynski 1990).

KEY WORDS: No Net Loss; Habitat compensation; Monitoring; Fisheries Act; Canada; File review

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In 2001, a comprehensive review conducted by the United States National Research Council (NRC) concluded that the goal of NNL of wetlands was not being achieved under the USACE Section 404 permitting program (NRC 2001). Reasons cited for the lack of success have included poor compliance with the conditions stipulated within the permits (Race and Fonseca 1996, Gallihugh and Rogner 1998, NRC 2001, Sudol and Ambrose 2002), an absence of appropriate follow-up monitoring and enforcement (Race and Fonseca 1996, Allen and Feddema 1996, NRC 2001, Cole and Shafer 2002, Sudol and Ambrose 2002), and a failure to adopt a landscape-level approach when permitting impacts to wetlands (Zedler 1996, Stein and Ambrose 1998, NRC 2001, Kelly 2001), among others. The failure of the Section 404 program to meet the goal of NNL has prompted scientists and resource managers to make a host of valuable recommendations aimed at improving operational and institutional practices relating to compensation (Race and Fonseca 1996, Allen and Feddema 1996, Brinson and Rheinhardt 1996, Stein and Ambrose 1998, Breaux and Serefiddin 1999, NRC 2001, La Peyre and others 2001).

Although the United States has not been successful in meeting their goal of NNL, scientists and resource managers have been diligent in evaluating the effectiveness of the Section 404 program and associated compensation practices and in promoting adaptive management in an effort to achieve NNL.

In Canada, Fisheries and Oceans Canada (DFO) applies the NNL principle when it issues an authorization under Section 35(2) of the *Fisheries Act* for a harmful alteration, disruption, and destruction of fish habitat (HADD) resulting from development activities. Guided by the *Policy for the Management of Fish Habitat* (the Habitat Policy; DFO 1986), DFO applies the NNL principle by requiring the proponent to balance unavoidable losses in the productive capacity of fish habitat that result from an authorized HADD through habitat compensation to prevent reductions in Canada's fisheries resources. Productive capacity is the measure of the capability of a habitat to produce fish and/or food organisms in natural or restored conditions, analogous to carrying capacity, which can be defined as the maximum biomass of organisms that can be sustained on a long-term basis by a given habitat (DFO 1998).

Since the Habitat Policy has been in place, DFO has conducted or commissioned only 10 studies that have evaluated the performance of habitat compensation projects in achieving NNL (Harper and Quigley 2005). A total of 103 compensation projects were assessed by these 10 studies, representing less than 4% of the total number of compensation projects in Canada (DFO 2003). Most of these studies assessed compensation projects that were specific to certain development, activities, habitat types, or compensation techniques, have been more qualitative than quantitative in nature, and have not been published in the peer-reviewed literature (Harper and Quigley 2005). As a result, a clear picture of whether NNL is being achieved in Canada does not exist.

In response, a national evaluation program designed to assess the performance of compensation projects in achieving NNL was initiated in 2000. As part of this program, files relating to *Fisheries Act* Section 35(2) authorizations issued by DFO were collected from across Canada and reviewed. Data extracted from these files were pooled and analyzed to provide an indication of what types of HADDs have been authorized in Canada, what habitats have been affected, and what habitat management approaches have been used when compensating for HADDs and monitoring and ensuring the success of the compensation. Proponent compliance with authorization requirements and the effectiveness of habitat compensation in achieving NNL were ascertained from the files.

Methods

Files relating to all of the *Fisheries Act* Section 35(2) authorizations (authorizations hereafter) issued in the Yukon, British Columbia, Manitoba, New Brunswick and Nova Scotia from January 1994 to December 1997 were compiled and reviewed (Figure 1). Files relating to five authorizations issued in Ontario within the same timeframe were also compiled and reviewed. Files were collected from these five provinces and one territory to provide a representative cross-section of habitat management practices within different regions across Canada. Files typically included the authorization, pre-impact assessment reports, engineering drawings, compensation plans, post-construction monitoring reports, photographic records of project development, and correspondence between the proponent and DFO. Authorizations issued from 1994 to 1997 were selected because it was anticipated that post-construction monitoring programs, which are typically required as part of an authorization in order to evaluate the success of the compensation project, would have been completed before this study was initiated. The mean duration of post-construction monitoring programs has been approximately 3.6 years (Harper and Quigley 2005). Compliance and effectiveness determinations for each project could then be made by reviewing the completed monitoring reports within the files.

Information pertaining to each authorization (Table 1) was entered into the Habitat Accounting Database (Harper and others 2001). After the information was entered and verified, we ran a set of queries to provide an indication of what types of HADDs have been authorized in Canada, what habitats have been affected, and what habitat management approaches were used when compensating for HADDs and monitoring and ensuring the success of the compensation. For each authorization, we attempted to determine whether the proponent was compliant with the stipulated mitigation, compensation, and monitoring requirements. A proponent was deemed to be compliant if all of the requirements had been met. We also attempted to determine whether a given project met the performance criteria that were stipulated by DFO in the authorization and whether NNL was achieved. These determinations were based on a review of pre- and post-construction monitoring reports, photographic records of project development, and correspondence between the proponent and DFO associated with each authorization. A project was deemed to have achieved NNL if these records could demonstrate that the areal extent, combined with the habitat productivity of the compensatory habitats, was

Figure 1. Canadian provinces and territory from which *Fisheries Act* Section 35(2) authorizations were collected.

equal to or greater than that of the habitats impacted by the HADD (or reference sites representing the habitats impacted by the HADD). Pre- and post-construction monitoring reports were classified into four different assessment classes developed for this study: Basic, Type 2, Type 1, or Research (Table 2).

Table 1. Information extracted from the authorizations and associated files

Project information	Project name Location of the project and UTM coordinates Name of the water body where the HADD occurred DFO contact and proponent responsible for the project
HADD information	Date the HADD was authorized and the valid authorization period Description of the HADD Development activity responsible for the HADD (e.g., forestry) Construction work(s) responsible for the HADD (e.g., culvert installation) Habitat value of the impacted habitat—marginal, important, critical (DFO 1998) DFO justification for accepting the HADD Compensation option(s) used (Harper and Quigley 2005) DFO justification for the compensation option chosen
Habitat information	HADD area(s) for each habitat type Compensation area(s) for each habitat type Compensation ratio = Compensation area(s):HADD area(s) Compensation technique(s) used Description of the compensation plan Species affected by the HADD and the compensation
Cost information	Cost of compensation works Cost of the monitoring program
Financial security information	Amount of financial security required Purpose of the financial security (e.g., to ensure compensatory works are completed) Duration of financial security Was the financial security exercised by DFO?
Proponent monitoring information	Assessment class of the pre-impact assessment Assessment class of the post-construction monitoring Duration of post-construction monitoring period Frequency of post-construction monitoring Assessment techniques used in post-construction monitoring Performance criteria for compensatory habitat Contingency measures if compensation fails Remedial measures taken as a result of compensation failure
DFO monitoring information	Did DFO conduct a pre-impact field check? Was the proponent compliant with mitigation measures? Was the proponent compliant with compensation measures? Was the proponent compliant with monitoring requirements? Was NNL achieved? Were the performance criteria met?
Report information	Citations and descriptions of reports on file

NNL: No Net Loss; HADD: harmful alteration, disruption, and destruction of fish habitat; DFO, Fisheries & Oceans Canada; UTM: Universal Transverse Mercator.

A simple classification of fish habitat types was devised based on descriptions of the habitat impacted by the HADD and compensation habitats within the authorizations. Fish habitat types described within the authorizations were grouped into six habitat categories: in-channel, off-channel, lacustrine, estuarine, marine, and riparian (Table 3). These six habitat categories encompass the environments upon which fish depend, directly or indirectly, in order to carry out their life processes. Habitat types within the in-channel, off-channel, and lacustrine habitat categories were described according to the functions they provided to fish (e.g., spawning or rearing). Habitat types within the estuarine and marine habitat categories were described according to tidal influence and substrate or vegetation (e.g., estuarine intertidal marsh habitat or marine subtidal rocky habitat). If the authorizations did not specify the function or physical attributes of the habitat, the habitat type was defined as unspecified (i.e., in-channel unspecified or estuarine unspecified). For each authorization, the total HADD area and compensation area as well as the HADD and compensation

Table 2. Assessment classes of pre- and post-construction monitoring.

Basic	Monitoring included a photographic record and/or on-site visual observations of HADD and compensation works. No field measurements or sampling were conducted.
Type 2	Monitoring included areal measurements of the HADD and/or compensation habitats and/or measurements that verify the proponent's compliance with the specified mitigation and compensation measures and performance criteria (e.g., 80% survival rate of riparian planting) found within the authorization.
Type 1	Monitoring included quantitative assessments of both the impacted and compensatory habitats. Assessments comprised areal measurements and estimates of productivity per unit area, determined by sampling a suite of ecological indicators such as invertebrate densities, fish biomass and densities, and riparian and aquatic vegetation growth rates. Pre- and post-construction comparisons of the physical areas and habitat productivities of the impacted habitats (or reference habitats representing the impacted habitats) and the compensatory habitats are conducted.
Research	Monitoring programs utilized an experimental design when evaluating compensation projects. Ecological indicators of habitat productivity were sampled for several years before and after the impacts occur within impacted habitats (or reference habitats representing the impacted habitats) and the compensatory habitats.

HADD: harmful alteration, disruption, and destruction of fish habitat.

Table 3. The six habitat categories, their definitions, and associated habitat types as described in the authorizations.

Habitat category	Definition
In-channel	All fish habitat occurring within the bankfull width of a stream or river channel. Habitat types included the following: Unspecified, Rearing and Spawning.
Off-channel	All fish habitat occurring within water bodies, such as side-channels, ponds, sloughs, oxbows and marshes, that are not part of the active channel, yet reside within the floodplain. Habitat types included the following: Unspecified, Rearing, and Spawning.
Lacustrine	All fish habitat situated within permanently flooded lakes, dammed river channels (e.g., reservoir), intermittent lakes, and tidal lakes with ocean-derived salinities below 0.5 parts per thousand (adapted from Cowardin and others 1979). Habitat types included the following: Unspecified, Rearing, and Spawning.
Estuarine	All fish habitat occurring within the seaward limit, defined by an imaginary line closing the mouth of a river, bay, or sound, and the upstream and landward limit where ocean-derived salts measure less than 0.5 parts per thousand during the period of average annual low flow (adapted from Cowardin and others 1979). Habitat types included the following: Intertidal Channel, Intertidal Marsh, Intertidal Mudflat, Intertidal Rocky, Subtidal Mudflat, Subtidal Rocky.
Marine	All fish habitat occurring within waters from the landward limit of tidal inundation and beyond the seaward limit of estuarine habitat with salinities exceeding 30 parts per thousand (adapted from Cowardin and others 1979). Habitat types included the following: Intertidal Channel, Intertidal Mudflat, Intertidal Marsh, Intertidal Rocky, Subtidal Mudflat, Subtidal Rocky.
Riparian	Habitat adjacent to the high watermark of in-channel, off-channel, lacustrine, estuarine, and marine habitats consisting of hydrophilic plant communities that directly influence the aquatic system via microclimate regulation, nutrient and organic matter loading, bank stabilization, and fine or large woody debris recruitment

areas within each habitat type were recorded. An overall balance of the reported HADD and compensation areas for each habitat type was also generated.

We also recorded whether the value of the habitat impacted by the HADD was identified by DFO as being critical, important, or marginal habitat. According to DFO's policy guidance (DFO 1998), critical habitat requires a high level of protection, important habitats require a moderate level of protection, and marginal habitats require a minimum level of protection. Qualitative factors such as the habitat's importance in sustaining subsistence, commercial or recreational fisheries, their rareness, their productive capacity, or the sensitivity of certain life stages of fish species using the habitat are considered when making a determination on the value of the habitat.

Descriptive statistics (mean ± SE) were used to summarize and describe the variables of interest in this

Table 4. The frequency and total area of HADDs and compensation in each habitat type as a result of the 124 authorizations

Habitat type	Frequency		Area (m^2)		
	HADDs	Compensation	HADDs	Compensation	Balance (m^2)
Estuarine—intertidal channel	1	1	—	—	—
Estuarine—intertidal marsh	7	7	30,020	52,940	22,920
Estuarine—intertidal mudflat	5	4	6309	8222	1913
Estuarine—intertidal rocky	5	3	4232	1681	−2551
Estuarine—subtidal rocky	1	4	200	1982	1782
In-channel—unspecified	61	46	153,150	284,387	131,237
In-channel—rearing	12	10	52,546	57,445	4899
In-channel—spawning	7	13	5732	8122	2390
Lacustrine—unspecified	3	4	16,059	246,400	230,341
Lacustrine—rearing	2	2	1250	128,450	127,200
Marine—intertidal channel	0	1	0	1440	1440
Marine—intertidal marsh	2	2	90	160	70
Marine—intertidal rocky	8	6	13,582	17,557	3975
Marine—subtidal mudflat	2	0	1570	0	−1570
Marine—subtidal rocky	1	3	125	7110	6985
Off-channel—unspecified	5	7	7138	9149	2011
Off-channel—rearing	8	19	8256	24,921	16,665
Off-channel—spawning	0	3	0	730	730
Riparian	87	84	119,303	169,642	50,339
Total	217	219	419,562	1,020,338	600,776

HADDs: harmful alterations, disruptions, and destructions of fish habitat.

study. An analysis of variance (ANOVA) was used to determine whether there were differences in mean monitoring durations and in compensation ratios among authorizations impacting marginal, important, and critical habitats. An ANOVA was also used to determine whether there were differences in mean HADD areas among different development activities. Regression analyses were used to determine whether there was a linear relationship between the monitoring duration and the HADD areas and compensation areas of the projects reviewed. Chi-square tests were used to test for differences in the frequency of HADDs among development activities and habitat categories, impacted habitat values (critical, important, marginal), selected compensation options from the hierarchy of preferences, and assessment classes of pre- and post-construction monitoring. Chi-square tests were used to determine whether there was a relationship between the retention of a financial security and compensation compliance, monitoring compliance, and the achievement of NNL by the compensation works. Where applicable, a log or square-root transformation was used to stabilize variability, and satisfy the normality assumptions of the residuals (Sokal and Rohlf 1981). All tests were considered significant if the p value was less than 0.05. All statistical analyses were performed using SAS statistical software, release 8.02 (SAS Institute 2001).

Results

File Review

Files relating to a total of 124 authorizations were collected. Of the 124 authorizations issued in the five provinces and one territory, 105 were from British Columbia, and of those, 83 occurred in the Fraser River Basin. Sixty of these occurred in the lower deltaic plain of the Fraser River. File quality was highly variable. In some instances, files were complete and included all of the associated monitoring reports, correspondence, and engineering drawings. However, in most cases, the files were incomplete and included only a copy of the authorization and some correspondence. Also, authorizations and associated files were typically not specific when identifying the type of habitat being affected by the HADD or compensation activities within a given habitat category; for example, files would specify losses and/or gains to in-channel habitat, but would rarely specify the functional or physical attributes of the in-channel habitat. Moreover, only 48% of the files included information regarding the fish species to be affected by the proposed habitat. None of the files included geographically referenced co-ordinates for site locations.

Fish Habitat Affected

The total HADD area as a result of the 124 authorizations was 419,562 m^2 (Table 4). The total com-

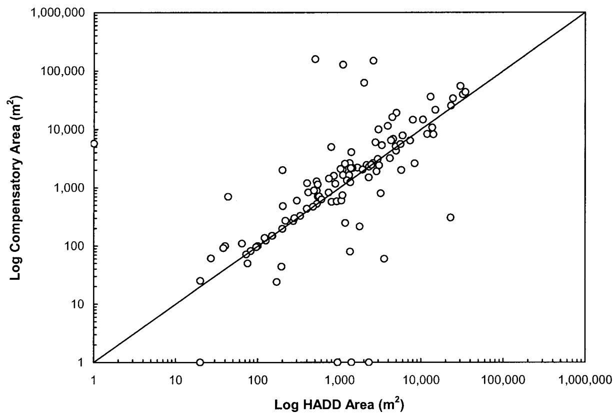

Figure 2. Compensation areas as a function of harmful alteration, disruption, and destruction of fish habitat (HADD) areas for 113 authorizations. Eleven authorizations were not included because HADD areas and/or compensation areas could not be quantified from the authorization files. A value of 1 m^2 was given to HADD and compensation areas that were recorded as 0 m^2 in the Habitat Accounting Database. The line on the figure represents Log Compensation Area = Log HADD Area (a compensation ratio of 1:1).

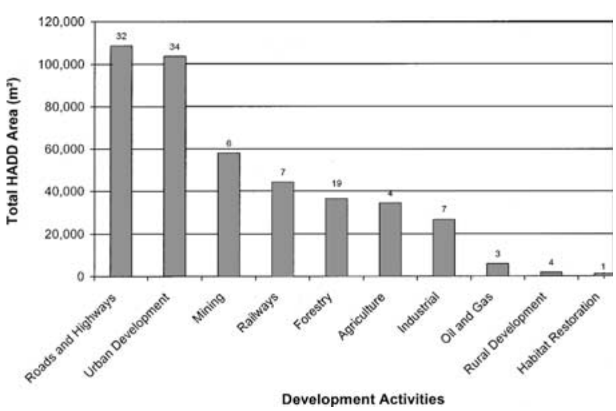

Figure 3. The total harmful alteration, disruption, and destruction of fish habitat (HADD) area and number of HADDs for each development activity.

pensation area to offset the 124 authorized HADDs was 1,020,338 m^2. In 41 instances (35 projects), the HADD and compensation areas within a given habitat type were not quantified, although there was evidence within the files that the given habitat type had been affected. Sixty-one percent and 24% of these nonreported areas occurred in the riparian habitat category and the in-channel habitat category, respectively.

The authorizations were issued for HADDs in 17 different habitat types and resulted in compensation in 18 different habitat types. The maximum number of habitat types affected by any one project was five and the mean number of habitat types affected per project was two. Overall, the riparian habitat category was the habitat category most frequently affected by HADDs and compensation, 40% and 38%, respectively (HADDs: $\chi^2 = 189.25$; df = 5; $p < 0.0001$; compensation: $\chi^2 = 142.61$; df = 5; $p < 0.0001$). Thirty-seven percent of the HADDs and 32% of the compensation occurred in the in-channel habitat category. By area, 50% of the total HADD area and 34% of the compensation area for the 124 authorizations were accounted for in the in-channel habitat category. Another 28% of the total HADD area and 17% of the total compensation area were accounted for in the riparian habitat category. Due to the significant amount of non-reporting of HADD and compensation areas in both the in-channel habitat category and the riparian habitat category, it is likely that HADD and compensation areas in these habitat categories are much higher than what is presented. Thirty-seven percent of the compensatory habitat by area was accounted for in the lacustrine habitat category. This is due to one project that resulted in a gain of 128,300 m^2 in the lacustrine rearing habitat type and one project resulting in a gain of 150,000 m^2 in the lacustrine unspecified habitat type.

Figure 2 illustrates compensation area as a function of HADD area for 113 authorizations. The median compensation ratio was 1.13:1. Eighty percent of the authorizations had compensation ratios of 2:1 or less, and 25% of the authorizations had a compensation ratio that was less than 1:1. Seventy-eight percent of the HADD areas and 72% of the compensation areas were less than or equal to 4000 m^2.

HADDs

The 124 HADDs that were authorized were a result of impacts from 10 different development activities and 24 different construction works. The development activities that resulted in the greatest percentage of HADDs included urban development, roads and highways, and forestry, 33%, 20%, and 18%, respectively ($\chi^2 = 149.76$; df = 10; $p < 0.0001$; Figure 3). The total HADD area was highest for roads and highways (108,740.4 m^2), followed by urban development (103,697.5 m^2) and mining (58,082.0 m^2). HADD areas did not differ among different land-use activities (ANOVA; df = 8,106; F = 1.00; $p = 0.442$).

Of the 24 different construction works impacting habitat, those associated with road and highway development, including culvert installations, bridge construction, and channel relocations, represented 47% of the total number of construction works resulting in HADDs. Sixty-five percent of the authorizations were a result of a single construction work, 33% were a result of a combination of two construction works, and 2%

Table 5. Frequency of use of compensation options from DFO's hierarchy of preferences[a]

Hierarchy	Frequency
1. Create in-kind (like) habitat	140
2. Increase in-kind (like) habitat productivity	61
3. Create out-of-kind (unlike) habitat	34
4. Increase out-of-kind (unlike) habitat productivity	13
5. Create or increase habitat in a different ecological unit, same species	9
6. Create or increase habitat in a different ecological unit, different species	1
7. Artificial propagation	0
8. Other	24

[a]The hierarchy of preferences is adapted from DFO Practitioner's Guide 2002.
DFO: Fisheries & Oceans Canada.

were a result of a combination of three or more construction works.

The value of the habitat impacted by the HADD was specified for 65% of the authorizations. Of these, 7% of the authorizations resulted in a HADD to critical habitat, 64% resulted in a HADD to important habitat, and 29% resulted in a HADD to marginal habitat ($\chi^2 = 116.90$; df = 3; $p < 0.0001$). Compensation ratios did not differ among authorizations for HADDs impacting critical, important, and marginal habitats (ANOVA; df = 2,39; F = 0.21; $p = 0.814$).

Approximately 20% of the authorizations had supporting rationales on file indicating why the HADD was acceptable to DFO and justifying why it could proceed subject to an authorization. Documented rationales typically indicated that compensation for the proposed HADD would result in a net gain in habitat, that the HADD was necessary for the protection of public safety or private land (e.g., streambank protection work), or that all other options for the proposed project and compensation had been exhausted and that the selected option for project development would have the least probable impact to fish habitat. Only four authorizations used the value of the habitat to be impacted as a rationale on why the HADD was acceptable.

Compensation

The compensation option that was most often selected from DFO's hierarchy of preferences (DFO 1986, DFO 1998) was creation of in-kind habitat (50%) ($\chi^2 = 346.11$; df = 6; $p < 0.0001$), the first option in the hierarchy of preferences (Table 5). Increasing in-kind habitat productivity and creation of out-of-kind habitat represented 22% and 12% of the selected compensation options, respectively. The least preferred hierarchy option, artificial propagation, was never used as a compensation option. In 24 instances, a compensation option other than those listed in the hierarchy of preferences was employed. Examples of these compensation options included restrictive covenants that prohibit development near fish habitat, compensation through fish habitat enhancement funds, cattle crossings, and storm water detention ponds.

Often proponents employed more than one compensation option when compensating for a HADD. Of the 124 authorizations reviewed, 48% indicated that only one compensation option was used, 36% indicated that two compensation options were used, and 16% indicated that three or more compensation options were used. Only 10% of the authorizations had supporting rationale on file justifying why a given compensation option from the hierarchy of preferences was used. It was expected, however, that the DFO biologist would not have provided supporting rationale for authorizations where the first option in the hierarchy of preferences, creation of in-kind habitat, was selected.

Fifteen percent of the authorizations documented the costs of the compensation. Costs for compensation for these authorizations ranged from $3,707 to $116,000, with a mean of $34,707 (SE = $7,092). Per unit area of compensatory habitat (m^2), the construction costs ranged from $0.24 to $1,074, with a mean of $85 (SE = $56).

Project Monitoring

Pre-impact assessments were conducted for 73% of the authorizations. For 5% of the authorizations, no pre-impact assessments were conducted, and for a further 22%, it could not be determined from the file review whether a pre-impact assessment had been conducted. Of the pre-impact assessments that were conducted, 12% were classified as Basic, 78% as Type 2, 9% as Type 1, and 1% as Research ($\chi^2 = 83.63$; df = 2; $p < 0.0001$).

Post-construction monitoring was required by DFO for 90% of the authorizations. It could not be determined whether post-construction monitoring was required for 4.0% of the authorizations. Of the post-construction monitoring that was required from the proponents, 5% was classified as Basic, 83% as Type 2, 11% as Type 1, and 1% as Research ($\chi^2 = 206.19$; df = 2; $p < 0.0001$). Post-construction monitoring as-

Table 6. Compliance and effectiveness percentages for the 124 authorizations

Result	Mitigation compliance?	Compensation compliance?	Monitoring compliance?	Performance criteria met?	NNL achieved?
Yes	32	59	43	30	10
No	6	2	48	11	4
Unknown	62	39	9	59	86

NNL: No Net Loss.

sessment class matched the pre-impact assessment class for only 56% of the authorizations, making before-and-after comparisons difficult and confounding our ability to make NNL determinations for most of the authorizations.

Eighty-three percent of the authorizations stipulated performance criteria for the compensation projects. Performance criteria varied depending on the habitat types affected. Examples included a minimum 80% survival rate for planted riparian vegetation over a specified period of time, fish utilization of a newly created off-channel habitat, physical stability of created in-channel habitat, or successful colonization of an artificial reef by marine plants and animals commonly found in the area. Performance criteria stating that NNL must be achieved occurred in only 6% of the authorizations. As a result, most of the post-construction monitoring was directed at demonstrating that the project had attained the performance criteria established by DFO rather than demonstrating whether NNL had been achieved by the project. For this reason, the majority of the post-construction monitoring fell into the Type 2 assessment class—an assessment class that typically does not allow for NNL determinations. Examples of typical Type 2 assessments included presence/absence fish sampling at newly created habitat structures, water quality monitoring, percent survival of planted vegetation, redd and spawner counts, and photographic records.

The duration of the monitoring programs associated with the authorizations ranged from 1 year to 12 years. The mean duration was 3.7 years (SE = 0.19; $N = 110$). The mean frequency of monitoring and reporting was once per year (SE = 0.02; $N = 103$). There was no relationship between the duration of monitoring and the size of the HADD ($R^2 = 0.03$; df = 1,101; F = 3.00; $p = 0.087$), the size of the compensation ($R^2 = 0.03$; df = 1,98; F = 2.96; $p = 0.088$), or the habitat value (ANOVA; df = 3,106; F = 0.66; $p = 0.577$). Compliance with monitoring requirements was poor. Monitoring requirements were met for only 43% of the authorizations (Table 6). A total of 210 monitoring reports were never submitted to DFO.

Financial Securities

Thirty-four percent of the authorizations required the proponent to submit financial securities to DFO in the form of letters of credit to ensure that the proponent would complete the proposed compensation works, the monitoring program, and any remedial works deemed necessary for the success of the compensatory works. Financial securities were only used in the province of British Columbia and the Yukon Territory. None of the financial securities were exercised by DFO. The smallest financial security retained by DFO was $2000, whereas the largest was $7 million. The mean amount for financial securities was $25,251 (SE ± $4484; $N = 37$). The amounts of five financial securities were removed as outliers in calculation of the mean (Sokal and Rohlf 1981). The mean duration of time that the financial securities were held was 3.1 years (SE ± 0.4:1; $N = 39$), and the range was 3 months to 11 years. There was no significant relationship between the retention of a financial security and compensation compliance ($\chi^2 = 1.91$; df = 2; $p = 0.352$), monitoring compliance ($\chi^2 = 5.21$; df = 2; $p = 0.087$), or achievement of NNL ($\chi^2 = 3.140$; df = 2; $p = 0.221$).

Compliance and Effectiveness

Compliance with stipulated mitigation and compensation measures within the file was difficult to ascertain for many of the compensation projects (Table 6). It was also difficult to ascertain whether the compensation projects had met the performance criteria within the authorization. Furthermore, in reviewing the files to determine the effectiveness of the compensation, it was only possible to make a NNL determination for 14% of the projects. A NNL determination could not be made for 86% of the projects. Our inability to make compliance and effectiveness determinations for most of the compensation projects was a result of a low compliance rate with monitoring requirements and the prevalence of monitoring in the Type 2 assessment class.

Remedial measures were carried out for 25 projects (20%) that did not achieve the stipulated performance criteria. Nineteen of the 25 projects requiring remedial measures required riparian replanting and re-seeding of stream banks, suggesting that the success of riparian planting is low. In each case, the need for remedial measures for these 25 projects was identified by their associated monitoring programs.

Discussion

Record Keeping

One of the main findings of this study was that file quality and record keeping was generally poor. Incomplete files and poor record keeping resulted in data gaps for many of the projects, making it difficult to establish patterns among compensation projects and draw conclusions about their effectiveness in achieving NNL. Few files had supporting rationales justifying why the HADD was acceptable to DFO and should be authorized under the *Fisheries Act* or why a given compensation option or compensation ratio was selected when compensating for a HADD. The importance of clearly documenting the rationales behind resource management decisions cannot be overstated. By not documenting the rationales behind its decisions, DFO leaves itself vulnerable to criticism from proponents and the public regarding the consistency and transparency of its decision-making with regard to fish habitat management. This criticism will only be magnified if the effectiveness of the habitat compensation in achieving NNL is limited. Moreover, a failure to properly document the rationales behind its decisions will compromise DFO's corporate memory, limit its organizational learning potential, and hamper its ability to effectively assess the outcomes of its decisions and manage adaptively. DFO would benefit from a standardized approach to recording information on habitat compensation projects. Although a database currently exists to track and record cursory information about authorizations (DFO 2003), consideration should be given to expanding this database to record the key project information that was recorded in the Habitat Accounting Database (Harper and others 2001) created for this study.

Habitat Impacts

On first inspection, it would appear that NNL of fish habitat has been achieved based on the total HADD and compensation areas reported within the authorizations. An estimated 600,776 m^2 of fish habitat has been potentially gained, and only two habitat types, lacustrine rearing habitat and marine subtidal habitat, sustained negative habitat balances. The total amount of fish habitat gained is somewhat misleading, however, because 501,120 m^2 of fish habitat was gained through four authorizations with exceptionally large compensation ratios. A quarter of the authorizations reviewed had compensation ratios that were less than 1:1. Thus, NNL is not occurring on an areal basis for a significant number of authorizations, and given the high degree of uncertainty in fish-habitat linkages (Minns and Moore 2003), it is also likely that the relatively small compensation ratios (median: 1.13:1) being applied may not have been sufficient to achieve the desired goal of NNL Interestingly, compensation ratios were not determined on the basis of habitat value. In fact, contrary to recent policy direction (DFO 2002), there was no difference in the compensation ratios for projects impacting critical, important, and marginal habitats. However, consistent with DFO policy direction concerning compensation for fish habitat (DFO 1998), DFO and the proponents most often selected the first compensation option in the hierarchy of preferences, the creation of in-kind habitat, when compensating for HADDs. The creation of in-kind habitat should, in theory, be the most effective option in maintaining or increasing the productive capacity of the affected habitat type.

In-channel and riparian habitats were the most frequently impacted in Canada. The primary reason for this is that the majority of the authorizations issued were for the loss of in-channel and riparian habitat resulting from the installation of stream crossings, such as culverts and bridges, as a result of road and highway development. Culvert and bridge installations and associated instream works continue to be the leading construction works affecting fish habitat across Canada (DFO 2003). Harper and Quigley (2000) demonstrated that the improper management of road and highway development can lead to a significant erosion of the habitat base through cumulative losses. Consideration should be given to developing national guidelines that provide effective and consistent mitigation and compensation strategies for impacts to in-channel and riparian habitats resulting from stream crossings and road and highway development. The development of effective mitigation and compensation strategies for impacts to riparian habitat is particularly relevant because it appears that riparian habitat may be one of the most difficult to compensate for, given the number of times that remedial measures were requested for riparian compensation. Also, riparian habitat may be considered by some as one of the least valued habitats, since areas of losses and gains of riparian habitat were often not reported within the files.

Compliance and Effectiveness

Poor record-keeping and low proponent compliance with monitoring requirements limited our ability to draw conclusions relating to proponent compliance with mitigation and compensation requirements. However, our inability to determine whether proponents were compliant with mitigation and compensation requirements is, in itself, an important finding. This finding demonstrates the need to improve the current system of record keeping in order to better track proponent requirements for compensation and monitoring. More importantly, greater emphasis should be placed on compliance monitoring and enforcement activities at an institutional level. These recommendations, however, are not novel and have been previously made in both Canada (Millar and others 1997, Drodge and others 2000) and the United States (Kusler and Kentula 1990, Sifneos and others 1992a, 1992b, Holland and Kentula 1992, Race and Fonseca 1996). Also, the use of financial securities to ensure proponent compliance warrants further attention. Although they were used by one third of the projects, none of the securities was exercised. Using financial securities to their full extent may have improved the proponent compliance record and ensured that projects were properly monitored or remediated.

The most alarming finding of this study was that a NNL determination, based on a review of the files, could only be made for 14% of the projects reviewed. Low proponent compliance with monitoring requirements limited our ability to determine the effectiveness of compensatory habitat in achieving NNL. Our findings indicate, however, that even if complete monitoring records were available for all of the authorizations reviewed, it still would not have been possible to make a NNL determination based on the results of the monitoring reports for the majority of the authorizations. Reasons for this include the selection of performance criteria that do not provide an indication of the effectiveness of the compensatory habitat in achieving NNL (e.g., presence/absence of fish in the compensatory habitat), failure of the pre-impact monitoring report to establish a proper baseline prior to the HADD, and a failure of the monitoring program to employ reference sites for comparative purposes when assessing the effectiveness of compensatory habitats. Minns and others (1996) state that ''the myth that the impact of habitat alterations can be assessed merely by regularly monitoring the treatment site before and after the alteration has great resilience and persistence.'' This was certainly evident from the files we reviewed. A reliable, standardized approach to designing and implementing monitoring programs that can assess the effectiveness of habitat compensation in achieving NNL does not currently exist (Cudmore-Vokey and others 2000).

Interestingly, similar conclusions regarding assessment approaches have been reached by scientists and resource managers in the United States examining the effectiveness of the Section 404 permitting program in achieving the goal of NNL of wetlands (Breaux and Serefiddin 1999, Ambrose 2000, La Peyre and others 2001). As a result, scientists and resource managers have proposed standardized performance criteria (e.g., Breaux and Serefiddin 1999), functional assessment procedures (for a summary, see NRC 2001), and the use of reference wetlands to provide performance benchmarks for created or restored wetlands (Brinson and Rheinhardt 1996). Although no single wetland assessment procedure has been adopted by resource managers in the United States, the NRC (2001) recommended that resource managers should replace wetland assessments that are based on subjective, best professional judgement with assessments that incorporate science-based, rapid assessment procedures. These assessments should assess the actual goals of wetland mitigation projects, scale assessment results to those from reference sites, be sensitive to temporal and spatial variability, and consider effects of position in landscape, among others. Also, impacted sites should be evaluated using the same functional assessment that was applied to the mitigation site (NRC 2001).

Similar approaches to assessing impacted and compensatory fish habitats should be adopted in Canada. Management actions, including fish habitat compensation projects, should be treated as experiments and monitoring programs should be adjusted accordingly in order to adopt a heuristic approach to habitat management (Minns and others 1996). Although sound scientific frameworks have been developed to determine whether and how a given habitat manipulation will affect the productive capacity of fish habitats (Jones and others 1996) and to assess the net change in the productive capacity of fish habitats that result from development projects and associated compensation activities (Minns 1997, Minns and Moore 2003), it is unlikely that DFO's practitioners will require proponents to incorporate these methodologies into their monitoring programs due to their inherent complexity. A practical, science-based approach to assessing the effectiveness of compensatory habitat in achieving NNL should be developed. Although this science-based approach may be more expensive than the current approach used in monitoring programs, the environmental cost of ineffective monitoring is far greater.

Conclusion

Overall, the findings relating to *Fisheries Act* Section 35(2) authorizations and fish habitat compensation in Canada are strikingly similar to those found by resource managers in the United States relating to *Clean Water Act* Section 404 permits and the compensatory mitigation of wetlands. Early studies examining the trends and patterns of Section 404 permits (Kentula and others 1992, Holland and Kentula 1992, Sifneos and others 1992a, 1992b) found that record keeping and the documentation of decisions made by resource managers were inadequate, that monitoring to ensure compliance was low, and that effective evaluations of compensatory mitigation projects are required to determine whether the goal of NNL is being achieved. Our findings indicate that DFO should improve its record-keeping and better document its management decisions, address poor proponent compliance through increased compliance and enforcement activities, and incorporate a standardized, science-based approach into monitoring programs to assess the effectiveness of fish habitat compensation projects in achieving NNL. Although this study has been a step in the right direction for DFO in terms of pursuing adaptive management, adequate resources, proper training, and standardized approaches to data management and monitoring programs are required to ensure that achieving the conservation goal of NNL in Canada is plausible.

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