Vol. 6: 239–249, 2009
doi: 10.3354/esr00160

ENDANGERED SPECIES RESEARCH
Endang Species Res

Printed March 2009
Published online January 26, 2009

National values for regional aquatic species at risk in Canada

Murray A. Rudd

Sir Wilfred Grenfell College, Memorial University of Newfoundland, Corner Brook, Newfoundland and Labrador A2H 6PN, Canada

ABSTRACT: The goal of the present analysis was to assess the geographic scope and magnitude of non-market values for 6 regional aquatic species listed, or being considered for listing, as endangered under the Canadian Species at Risk Act. I used latent class analysis to partition responses from a national Internet-based survey that asked respondents about their preferred conservation program from amongst scenarios that varied according to target species (Atlantic salmon *Salmo salar*, Atlantic whitefish *Coregonus huntsmani*, leatherback turtle *Dermochelys coriacea*, North Atlantic right whale *Eubalaena glacialis*, porbeagle shark *Lamna nasus*, and white sturgeon *Acipenser transmontanus*), program performance, cost, and method of payment. The large sample of the Canadian public (n = 2761) cleaved into 9 distinct segments that varied significantly in their patterns of preferences. Mean implicit prices, calculated using regression coefficients, ranged as high as CAD $85.99 annually for Atlantic salmon *Salmo salar*. There was strong support for programs that had a high probability of success even though increases in population abundance and improvements in listing status were each only significant for 4 of the 9 segments. I also found evidence that members of 1 segment were unwilling or unable to make tradeoffs between the program attributes (i.e. they exhibited 'lexicographic preferences'). Members from all 9 segments were distributed across Canada, implying that the proper geographic scope of benefits assessments should be expanded beyond the regions in which regional aquatic species at risk actually occur. These findings should help ensure that the broad societal benefits of conservation are captured when making endangered species listing and investment decisions in Canada in the future.

KEY WORDS: Endangered species · Passive use value · Choice experiment · Species at Risk Act · Internet survey · Latent class analysis

INTRODUCTION

Aquatic animals in Canada are increasingly at risk due to habitat degradation, overexploitation, pollution, and disruption from invasive species (Venter et al. 2006). The Species at Risk Act (SARA) was proclaimed in 2003 in response to the loss of Canadian plants and animals. It is intended to prevent species from becoming extirpated or extinct, to provide for their recovery, and to encourage the management of other species to prevent them from becoming at risk (Environment Canada 2003). Listing species under SARA requires government departments to 'assess regulatory and non-regulatory options to maximize net benefits to society as a whole' (TBS 2007, p. 1).

The costs of protecting biodiversity are often quantifiable and impact a small number of resource users and communities at the municipal or regional scale. The local benefits of biodiversity conservation often tend to be modest, while non-market benefits derived at the national and international scale can be substantial (Hein et al. 2006). Benefits for species at risk may include non-extractive use values for species attractive for recreational purposes (i.e. viewing or catch-and-release fishing), indirect use values (e.g. contributions of species at risk to the regulation of commercial species), option and quasi-option values (i.e. the value of

*Email: mrudd@swgc.mun.ca

use of, or information from, the species in the future), or non-use value (Pearce & Moran 1994). Non-use values include passive use benefits arising simply because citizens know that efforts are being made to protect endangered species at risk, now and for the future. In the Canadian context, not quantifying the full range of benefits, including the passive use benefits, to Canadian society as a whole could lead to biases against listing and investments in SARA conservation initiatives (Mooers et al. 2007).

The Canadian government's decision not to list the porbeagle shark as an endangered species illustrates how a focus on local costs in the conservation cost-benefit calculus may underestimate the net societal benefits of listing. In that case, financial costs to fishers and fishing communities were identified as a primary reason not to list the porbeagle shark (Government of Canada 2006), even though only 2 fishers in Atlantic Canada derived more than 25% of their gross income from fishing porbeagle in 2005 and porbeagle landings accounted for a mere 2% of landed value in a single Nova Scotia fishing community (DFO 2006). The national benefits of conservation were identified in the report, but not quantified.

Stated-preference valuation methodologies that can quantify citizens' willingness to pay (WTP) for changes in public good provision are functionally the only approach by which the broad societal economic benefits arising from passive use can be estimated (Pearce 1998). The most well-known stated-preference approach, contingent valuation methodology (CVM), became prominent in the aftermath of the 1989 Exxon Valdez oil spill (Carson et al. 2003) and has been used extensively in biodiversity valuation research (e.g. Stevens et al. 1991, Kotchen & Reiling 2000, Tisdell et al. 2005, Ojea & Loureiro 2007). Two meta-analyses (Loomis & White 1996, Martín-López et al. 2008) provide comprehensive overviews of CVM research on endangered species. Rapid theoretical and methodological advances (Train 2003) have recently led to the choice experiment (CE) becoming a preferred tool for assessing nonmarket benefits (Hanley et al. 2001); both CVM and CE approaches share the same underlying random utility theory framework (McFadden 1974). Choice experiments can be used to value multiple attributes of conservation policy initiatives simultaneously, and biodiversity has been one focus of recent ecosystem services-oriented CE research (e.g. Birol et al. 2006, Christie et al. 2006, Milon & Scrogin 2006).

My goals were to assess the geographic scope and magnitude of non-market values for 6 regional aquatic species listed, or proposed for listing, as endangered in Canada and examine the relative importance of passive use versus non-extractive use benefits for Canadians. I asked the following questions: (1) Does willingness to support and pay for aquatic species at risk conservation vary amongst different segments of Canadian society? (2) What program attributes influence citizens' WTP for SARA conservation initiatives? (3) What is the proper geographic scope of analysis for assessing the passive use benefits of conservation for select regional aquatic species at risk? An Internet-based choice experiment targeting the Canadian public (n = 2761) was conducted nationally in 2006 to address these questions. The outcomes from this research should help inform the SARA policy process, ensuring that the broad societal benefits of conserving aquatic species are adequately considered when making SARA listing decisions in the future.

MATERIALS AND METHODS

Theoretical background. Assume that household decision makers face M discrete alternatives (A_1, A_2, …, A_M) relating to conservation programs for aquatic species at risk, each of which provides a certain level of utility (u) and that the utility derived from each alternative A_m is denoted as u_m. In a random-utility model (McFadden 1974), utility can be decomposed to $u_{im} = v_{im} + \varepsilon_{im}$, where v_{im} is the systematic or observed component of utility for each individual (i) and ε_{im} captures factors that are unobserved by the researcher. Because a researcher does not know the unobserved portion of utility for each person, the error terms are treated as random.

If one assumes that the error term is independently and identically extreme-value distributed (IID) and specifies utility as being linear in parameters, the resulting probability of choice is described by the standard conditional logit model. There has been increasing interest in random parameter logit and latent class (LC) logit models to explicitly account for respondent heterogeneity in preferences at individual and subpopulation levels, respectively (see Train [2003] for a thorough discussion of error assumptions and modeling implications). The LC logit model captures respondent heterogeneity by simultaneously estimating logit coefficients and partitioning the sample into LCs within which the IID assumption holds (e.g. Boxall & Adamowicz 2002, Birol et al. 2006, Milon & Scrogin 2006).

Given choice data for I individuals and the value of the dependent variable (y), conservation program choice y_i can take on values $1 \leq m \leq M$ (M refers to the total number of programs available, while m refers to particular programs). I considered 2 types of explanatory variables in this analysis: (1) attributes of conservation programs for individual i and alternative m (denoted by z_{imr}^{att}, where r is an index used to refer to the rth of R attributes) and (2) covariates for each individual i (denoted by z_{is}^{cov} where s is an index used to refer to particular covariates). For K LCs, denoted as x ($1 \le x \le K$) and with scale factor normalized to 1, the probability (Pr) that individual i in segment k selects alternative m given the vector of attributes and covariate values is

$$\Pr(y_i = m \mid x, z_i^{att}) = \frac{\exp(v_m \mid x, z_i)}{\sum_{m'=1}^{M} \exp(v_{m'} \mid x, z_i)} \quad (1)$$

The systematic component of utility, ($v_m \mid x,\ z_i$), of alternative m given that case i belongs to LC x is usually modeled linearly as

$$v_m \mid x, z_i = \beta_{xm} + \sum_{r=1}^{R} \beta_{xr}^{att} z_{imr}^{att} \quad (2)$$

where β_{xm} is an intercept corresponding to alternative m for each LC x. The unconditional probability of belonging to LC x depends on the set of covariates and can itself be specified by a second multinomial logit in which class membership is regressed on covariates:

$$\Pr(x \mid z_i^{cov}) = \frac{\exp(v_x \mid z_i)}{\sum_{x'=1}^{K} \exp(v_{x'} \mid z_i)} \quad (3)$$

A linear term is used to model the effect of the qth of Q covariates for class x (γ_{qx}), and γ_{0x} is an intercept corresponding to LC x:

$$v_{x|z_i} = \gamma_{0x} + \sum_{q=1}^{Q} \gamma_{qx} z_{is}^{cov} \quad (4)$$

Both regressions were estimated simultaneously with Latent Gold Choice 4.0 (Vermunt & Magidson 2005). To correct for non-representative sample response patterns, I used sampling weights and a pseudo-maximum likelihood estimator. Wald tests were used to assess whether sets of coefficients were jointly significantly different from 0 and whether sets of attribute coefficients were equal across classes. LC conditional logit coefficients describe the marginal tradeoffs that decision makers in each segment are willing to make between attributes. The implicit price (or WTP) for marginal changes in any attribute m can be calculated with the ratio β_m/β_{fee} when a fee is included as one of the attributes describing choice alternatives.

Survey design and delivery. Choice experiments ask survey respondents to choose the single option they most prefer from a number of possible options. Each profile (option) is defined by its attributes, and each attribute can take on a number of levels. In this survey, respondents were asked to complete choice tasks that each contained 2 conservation program profiles (Options A and B). In all cases, a zero-cost opt-out choice (Option C) allowed respondents to indicate they would not choose either alternative (Fig. 1). Six choice attributes for this survey were finalized after extensive expert review, input from 2 focus groups, and testing of multiple versions of French and English pilot surveys.

The first conservation program attribute was target species. It included 4 species that occur exclusively on the Atlantic coast in Canada (Atlantic salmon *Salmo salar*, Atlantic whitefish *Coregonus huntsmani*, North Atlantic right whale *Eubalaena glacialis* and porbeagle shark *Lamna nasus*), 1 that occurs on both coasts (leatherback turtle *Dermochelys coriacea*), and 1 that is present only on the Pacific coast (white sturgeon *Acipenser transmontanus*). Other conservation program attributes included population abundance (50, 100, or 200% increase from status quo), listing status (remain as endangered = 1 or improve to threatened = 2), funding mechanism (increase in annual household taxes = 1 or reallocation of current taxes from other government spending = 2), annual cost (CAD \$0.50, \$1.00, \$2.50, \$5.00, \$10.00 or \$20.00 yr^{-1} [at the time of the survey, CAD \$1.00 = USD \$0.87; unless otherwise stated all dollar values given hereafter are CAD \$]) to the household for the duration of the 20 yr^{-1} conservation program, and probability of program success (50% ['50/50 odds'], 75% ['somewhat likely'], and 100% ['a sure thing']). Effects coding was used for the analysis, resulting in regression coefficients that are zero-centered for nominal variables (i.e. indicating the relative attractiveness or unattractiveness of 1 species relative to others).

A 72-level mixed orthogonal array (Zhang et al. 2001) was the smallest possible main effects experimental design for this combination of attributes and levels (MA.72.2.8.3.12.4.1.6.4 from N. Sloane's orthogonal array library, www.research.att.com/~njas/oadir/index.html). The 72 questions were divided into 8 blocks of 9 questions each, to which respondents were assigned randomly.

The Internet-based survey instrument consisted of 5 sections: (1) an introduction, including information about the purpose, voluntary nature, and confidentiality of the survey; (2) Likert-scale ratings of general respondent opinions; (3) choice experiment tasks; (4) follow-up questions; and (5) respondent demographics (the English version of the survey is available for review at www.swgc.mun.ca/research/evpl/Pages/survey_species-at-risk.aspx). Supporting information (e.g. definitions, help files, and relevant government background documents) was provided to respondents through hyperlinks. The Sawtooth Software SSI survey platform was used to deliver the survey.

A USA-based Internet panel provider (GMI, www.gmi-mr.com) supplied the sample from its Canadian Internet panel of over 100 000 households nationwide.

If these were the only recovery programs available, which would you choose?

	Option A	Option B	Option C
Target Species	Right Whale	Atlantic Whitefish	NONE : If these programs were my only two choices, I would not be willing to support either of them
Population Abundance	50% Increase	50% Increase	
Listing Status	Threatened (better)	Threatened (better)	
Method of Funding Recovery Program	Increase Household Income Tax	Government Spending is Reallocated	
Annual Cost (per household)	$20.00 per year (for 20 years)	$1.00 per year (for 20 years)	
Probability of Success	100% ('sure thing')	50% (50/50 odds)	
	❍	❍	❍

Click the button below your preferred choice

Fig. 1. Example of a single choice task (of 9 tasks in total) in the Internet-based survey. Underlined program attributes denote hyperlinks to approved government documents and help files

Potential survey respondents were invited by GMI to visit the survey website, where they could then enter the survey if they so chose. The Canadian panel is broadly representative of the general population but because there is an opportunity for respondent self-selection, the sample is not equivalent to a random sample of the Canadian population. Internet panels have been increasingly used for Canadian environmental and agricultural economics research over the past 5 yr (e.g. Hu et al. 2004, 2006). Internet penetration in Canada is amongst the highest in the world (Statistics Canada 2008). In 2007, over 70% of all Canadians used the Internet, with higher use rates in metropolitan areas where the vast majority of Canadians live.

Demographic data collected included age category (combined into groups of <30, 30 to 39, 40 to 49 and 50+ yr), gender (female = 1, male = 2), household income (combined into groups of <$30 000, $30 000 to $59 999, and $60 000+), language (English = 1, French = 2), self-reported familiarity with SARA (low = 1 and moderate/high = 2), and postal code (effects coding was used for categorical variables, resulting in regression coefficients that were zero-centered). The Statistics Canada (2004) Postal Code Conversion File was used to georeference respondents' residence by province and rurality: census metropolitan areas (core urban areas with populations of over 100 000), census aggregations (smaller urban areas, adjacent municipalities), rural areas with strong metropolitan influence (>30% of residents commute to urban areas for work), and rural areas with weak metropolitan influence (<30% commuting). Time (min:s) to complete the survey (fast, 5:25 to 11:46; moderate, 11:47 to 18:37; and slow, ≥18:38) was tracked and used as a covariate. An Atlantic salmon-fisher indicator was also included as a covariate (non-fishers = 1, fishers [i.e. had either fished for Atlantic salmon in the past or expressed a desire to fish for Atlantic salmon in the future] = 2).

RESULTS

Surveys were collected in 2 waves of sampling, between 7 and 10 February 2006 in Atlantic Canada and between 13 and 17 March 2006 in the rest of Canada. A total of 3983 people visited the survey website (the Internet panel provider did not provide information on how many households they distributed survey notices to). The 58 people who took <5:25 min to complete the survey (the fastest 2.5%) were dropped from the analysis. Eighty-three participants were also dropped from the analysis because they chose the opt-out option for all choice tasks and they selected the opt-out choices for protest reasons (e.g. they did not think the government would use the funds wisely). In total, 2761 valid completed surveys were available for the final CE analysis (69.3% of respondents that visited the survey website).

For the final CE analysis, I aggregated province of residence into 5 geographic areas: Atlantic Canada (n = 661), Quebec (n = 532), Ontario (n = 657), Prairie Provinces (n = 670), and British Columbia/Yukon (n = 241). There was a significant difference in region of residence between the Canadian population and survey respondents (χ^2 = 2044.5, $p < 0.0001$), largely a result of deliberate oversampling in the Atlantic region during the first wave of sampling. Age categories (χ^2 = 726.4, $p < 0.001$) and gender breakdown (χ^2 = 14.80, p = 0.0001) in the sample were also significantly different from the Canadian population. Sample weights were therefore used in subsequent analyses to correct for imbalances in region of residence, age, and gender. Although the sample was also non-representative along other dimensions (income [χ^2 = 232.3, $p < 0.001$] and language [χ^2 = 99.6, $p < 0.001$]), further corrective weightings were not applied.

Incorporating LCs significantly improved model fit and performance from the 1-class model (the standard conditional logit). A 9-class LC logit model minimized Bayesian Information Criterion (BIC). While alternative test statistics (Akaike Information Criteria, AIC and AIC3) suggested better fit using a 12-class model, the 9-class model was more parsimonious and was therefore chosen as the final model (Table 1). While all coefficients are of reasonable magnitude and of the correct sign in the 1-class conditional logit model, the 9-class LC logit model captures much more complex preference patterns amongst respondents. The frequency that members of each LC chose Option C, the opt-out, is also shown in Table 1.

Wald statistics were highly significant for species and all other conservation program attributes, indicating that members of the 9 LCs differed significantly in their conservation program preferences and, consequently, their willingness to support and/or pay for various conservation programs. Coefficients for the 6 species reflected preferences relative to one another; they are zero-centered, with more preferred species having positive coefficients and less preferred species having negative coefficients.

Funding mechanism coefficients were positive and significant for 7 of 9 classes, signifying strong preferences for conservation programs funded with reallocation of existing tax dollars rather than with new household taxes. The coefficient for probability of success was also positive and significant for 7 of 9 LCs. Coefficients for change in listing status and population abundance, however, were positive and significant for only 4 of 9 LCs each. For LC 9, the coefficient for a change in listing status, improving from endangered to threatened, was significant and negative, contrary to *a priori* expectations. Cost coefficients were negative for all segments, in line with *a priori* expectations, but were significant for only 8 of 9 LCs (all except LC 5).

The significant, negative value of the 'none' option for LC 2 acted as a baseline utility shifter. With the large negative coefficient, even the worst conservation program option, a poorly performing program focused on porbeagle shark, was strongly preferred to no conservation action. LCs 4, 6, 7, 8, and 9, on the other hand, had positive 'none' coefficients. This suggests that respondents in these LCs had utility thresholds that would need to be surpassed in order for them to support SARA conservation programs. That is, even if coefficients for conservation program attributes were significant and positive, it does not necessarily follow that a respondent would pay for an improvement in conservation outcomes unless the necessary threshold for support was exceeded.

For covariates, hypotheses that age, income, the Atlantic salmon-fisher dummy variable, region, and self-reported familiarity with SARA were each jointly equal 0 across LCs were rejected at the 1% level (and language at the 5% level). Hypotheses that gender, rurality, and survey completion time were each jointly equal 0 across LCs could not be rejected (Wald $p > 0.10$).

The implicit prices (mean WTP) of the program attributes are shown in Table 2 (WTP for attribute 5 is not quantified because the cost coefficient was not significant). For a representative respondent in LC 1, for example, a conservation program focusing on the leatherback turtle would add $22.74 in value compared to the least preferred species (Atlantic whitefish). Put another way, the average LC 1 respondent would be indifferent between the implementation of a SARA conservation program costing an additional $22.74 and focusing on leatherback turtle versus a program focusing on their least-preferred species, Atlantic whitefish.

DISCUSSION

LC membership reflects fundamental, unobserved differences in the underlying values and preferences of survey respondents that are often masked using standard conditional logit models (Milon & Scrogin 2006). LC logit models can, relative to standard 1-class conditional logit models, provide deeper insights into the tradeoffs between financial well-being and environmental quality that different segments of larger populations are willing to make. In this study, I found respondent heterogeneity, suggesting that Canadians have complex preferences regarding species at risk conservation and recovery. As such, the results from this survey provide important information about the potential magnitude of non-market economic benefits arising from SARA listing and recovery as well as insights into potential support for (or opposition to)

Table 1. Regression coefficients for choice attributes and covariates for the 1-class (standard conditional logit) and 9-class latent class (LC) models of Canadians' aquatic species-at-risk conservation program preferences. LC1–LC9: latent classes 1 to 9; BIC: Bayesian Information Criterion. The Wald statistic tests the restriction that each of the parameter estimates in that set equals zero across LCs, while the Walld(=) statistic tests the equality of each set of regression effects across LCs. Significance level of coefficients denoted as *, **, and ***, for 10, 5, and 1%, respectively

	Conditional logit	9-class LC model										
	(1-class)	LC 1	LC 2	LC 3	LC 4	LC 5	LC 6	LC 7	LC 8	LC 9	Wald	Wald (=)
Segment size (%)	100	21.7	17.3	12.5	12.4	11.1	7.5	6.0	5.8	5.7		
Proportion of choices												
Option A	0.415	0.485	0.495	0.479	0.314	0.486	0.359	0.303	0.089	0.373		
Option B	0.416	0.497	0.487	0.484	0.319	0.489	0.336	0.278	0.087	0.392		
Option C (opt-out)	0.170	0.018	0.018	0.037	0.367	0.025	0.306	0.419	0.824	0.235		
Choice attributes												
Species[a]												
Atlantic salmon	0.552***	0.113	1.743***	−0.168	0.815***	0.265	3.168***	0.237	1.591***	0.255	759.0***	507.4***
Atlantic whitefish	−0.061	−0.509	0.406	−0.812***	−0.428	−0.153	1.392	−0.114	0.432	0.487		
Leatherback turtle	−0.066	0.480***	−1.103	0.493	0.035	0.753	−1.702	−0.154	0.390	−0.714**		
Porbeagle shark	−0.574***	−0.091	−1.181***	−0.012	−0.849***	−1.120***	−2.452***	−0.352**	−1.534**	−0.535		
N. Atlantic right whale	0.239	0.345	−0.240	0.448**	0.633	1.285***	−1.009	−0.091	0.374	0.438*		
White sturgeon	−0.090	−0.338***	0.377	0.050	−0.207	−0.951	0.603	0.475	−1.254	0.069		
Δ population abundance	0.171***	0.579***	−0.013	0.446***	0.151**	−0.003	−0.010	0.379***	0.157	−0.230*	94.7***	63.9***
Δ listing status	0.220***	1.151***	−0.107	−0.608	0.618***	−0.294	0.335**	0.578**	−0.054	0.065	121.1***	94.4***
Funding mechanism	0.560***	0.568***	0.504***	1.019***	0.635***	0.107	0.528***	0.636**	0.316	4.822***	238.3***	151.3***
Cost to household	−0.055***	−0.044**	−0.059***	−0.203***	−0.047***	−0.016	−0.066***	−0.596***	−0.163***	−0.036**	164.3***	83.6***
Probability of success	1.716***	4.007***	1.599***	4.122***	2.281***	0.819	1.035***	2.517***	0.321	2.133***	280.4***	36.0***
None (opt-out)	0.663***	0.908	−2.381***	−0.219	2.472***	−2.607***	0.843**	1.411**	2.511***	3.071***	230.5***	218.4***
Covariates												
Constant		3.369***	−1.123*	2.156***	0.037	−1.143	−1.952*	−1.309*	0.911	−0.946	56.8***	
Age		−0.472***	0.132*	−0.441***	−0.002	0.136	0.724***	−0.203	0.147	−0.022	116.7***	
Gender		−0.116	0.220	−0.078	−0.204	−0.143	0.309	0.144	0.001	−0.134	6.3	
Income		−0.032	0.108***	−0.057	−0.054	−0.059	0.016	0.040	−0.060	0.098**	29.1***	
Fisher		−0.084	0.569***	−0.513	0.215	0.177	0.545**	−0.519	−0.513	0.123	20.6***	
Region of residence												
Atlantic Canada		0.079	0.507***	−0.377	0.345	−0.240	−0.251	−0.070	−0.207	0.215	65.9***	
Quebec		0.300	−0.026	0.309	−0.370	0.187	0.375	−1.096***	0.182	0.140		
Ontario		−0.208	−0.056	0.005	0.092	0.078	−0.141	0.348*	−0.148	0.028		
Prairie provinces		0.094	−0.358**	−0.068	0.097	−0.073	0.008	0.414**	−0.221	0.107		
British Columbia		−0.264	−0.067	0.131	−0.164	0.048	0.008	0.404	0.394	−0.490		
Urban-rural residence												
Census metropolitan area		0.092	−0.047	−0.076	0.015	0.290	−0.281	−0.079	0.132	−0.044	24.2	
Other metropolitan area		0.098	−0.022	−0.453	−0.328	0.300	0.168	0.163	0.234	−0.159		
Strongly influenced rural		0.072	0.079	0.314	0.351	−0.389	0.224	0.074	−1.158**	0.434*		
Weakly influenced rural		−0.262	−0.010	0.216	−0.037	−0.201	−0.110	−0.157	0.792***	−0.231		
Language		−0.619*	0.254	0.054	0.736	−0.040	−1.212**	1.028***	−0.420	0.219	19.2**	
Time		0.001	0.001	0.000	0.002	−0.001	−0.002	0.002	−0.005**	0.000	8.2	
Expertise		0.064	0.015	0.054	−0.098	0.831***	−0.178	0.015	−0.735***	0.032	27.0***	
Model performance												
Sample size	2761						2761					
Number of observations	24 849						24 849					
Number of parameters	11						219					
Log-likelihood	−23 355.0						−19 301.7					
BIC	46 797.1						40 338.6					
Pseudo-R^2	0.163						0.493					

[a]Only the significance level (relative to the zero-centered mean) for the most and least preferred species are shown

Table 2. Implicit price (mean willingness to pay [WTP] in 2006 Canadian dollars) for aquatic species at risk conservation program attributes. At the time of the survey, CAD \$1.00 = USD \$0.87. Cost coefficient was not significant for LC 5, so implicit prices are not reported. Implicit prices for species are reported relative to least preferred species; other implicit prices are reported only where underlying attribute coefficients were significant at the 10% level or better

	Conditional logit (1-class)	9-class latent class (LC) model: LC 1	LC 2	LC 3	LC 4	LC 5	LC 6	LC 7	LC 8	LC 9
Most preferred species	Atlantic salmon	Leatherback turtle	Atlantic salmon	Leatherback turtle	Atlantic salmon	N Atlantic right whale	Atlantic salmon	White sturgeon	Atlantic salmon	Atlantic whitefish
Least preferred species	Porbeagle shark	Atlantic whitefish	Porbeagle shark	Atlantic whitefish	Porbeagle shark	Porbeagle shark	Porbeagle shark	Porbeagle shark	Porbeagle shark	Leatherback turtle
Implicit price (\$) of attributes										
Species										
Atlantic salmon	20.62	14.30	49.73	3.18	35.33	–	85.79	0.99	19.23	26.71
Atlantic whitefish	9.40	–	26.99	–	8.92	–	58.69	0.40	12.10	33.11
Leatherback turtle	9.30	22.74	1.33	6.44	18.77	–	11.44	0.33	11.84	–
Porbeagle shark	–	9.61	–	3.95	–	–	–	–	–	4.94
Right whale	14.89	19.64	16.00	6.22	31.46	–	22.03	0.44	11.74	31.75
White sturgeon	8.87	3.94	26.50	4.25	13.63	–	46.63	1.39	1.72	21.57
Δ population abundance	3.14	13.31	–	2.20	3.21	–	–	0.64	–	(6.33)
Δ listing status	4.04	26.45	–	–	13.13	–	5.12	0.97	–	–
Funding mechanism	10.25	13.06	8.57	5.03	13.48	–	8.07	1.07	–	132.83
Probability of success	31.43	92.11	27.20	20.36	48.43	–	15.80	4.22	–	58.76

conservation policies amongst various segments of Canadian society.

I used sample weights to correct for age, gender, and regional disparities in the sample, but additional biases in coefficient and WTP estimates may be present because the national sample was not representative of the Canadian population in terms of income level (under–representation of lowest and highest income levels) and language (under-representation of French respondents). Even corrective weightings for demographic variables are unlikely to yield a fully representative sample in Internet surveys due to imbalances in Internet access and capacity amongst elderly and low-income citizens (Couper et al. 2007), so it would be inappropriate to use results from this survey to derive an overall national average WTP or aggregate consumer surplus estimate for the conservation of aquatic species at risk. Still, large Internet panel samples are particularly well-suited for quantifying subtle differences in opinion and preference (Alvarez et al. 2003). My primary focus in this research was on the differences in preferences and values between demographically distinct segments within the overall population and on the geographic distribution of respondents within those segments. Slight biases due to the use of approximately representative, rather than random, sampling are unlikely to lead to any changes regarding preference patterns or conclusions as to the general magnitude of passive use benefits of protecting and recovering aquatic species at risk in Canada.

Willingness to pay for conservation program attributes

Atlantic salmon were the most preferred species for 4 of the 9 LCs, whereas leatherback turtle were most preferred for 2 segments, and North Atlantic right whale, Atlantic whitefish and white sturgeon were most preferred for 1 segment each. LCs 2 and 6 had the largest range in species preference, with implicit prices for Atlantic salmon (versus porbeagle shark) of \$49.73 and \$85.79, respectively. That is, the average respondent in these LCs would be willing to pay \$50 to \$86 more for SARA programs targeting Atlantic salmon than for programs targeting porbeagle shark if other aspects of program performance were the same. For both segments, the Atlantic salmon fishing coefficients were similar in magnitude (0.569 for LC 2 and 0.545 for LC 6) and significant. The high WTP for Atlantic salmon in these 2 segments likely arises because of a mix of use value (i.e. catch-and-release sport fishing), option value (i.e. keeping the sport fishing option available in the future), and passive use value (i.e. species existence and bequest values for future generations).

I took a different approach to the valuation of endangered species compared to previous studies, defining target species as one of several attributes of an overall conservation program. As such, my WTP figures may not be directly comparable with other studies that derive WTP for a given change in population abundance on an 'all or nothing' basis. Nonetheless, the WTP estimates from this survey do not seem unreasonable. In a recent meta-analysis, Martín-López et al. (2008) summarized WTP estimates from 60 CVM studies; values typically ranged from USD $15 to $100+ annually for marine fishes and mammals. Kotchen & Reiling (2000), for example, estimated a mean annual WTP of US $26.63 for restoring a self-sustaining, breeding population of shortnose sturgeon *Acipenser brevirostrum*. In my study, the incremental value of white sturgeon (relative to the least preferred species) ranged from $1.39 to $46.63 for SARA conservation programs similar in all other respects.

Although I do not aggregate implicit prices for different species to calculate changes in consumer surplus under alternative policy scenarios, it is clear that non-extractive and passive use values for these aquatic species at risk are substantial. For example, a conservation program targeting the porbeagle shark, the least preferred species in the survey for 6 of 9 LCs, still provides passive use benefits (it is not caught by sport fishers) to over 39% of the national sample (WTP of $9.61 and $3.95, relative to Atlantic whitefish, for LC 1 and LC 3, respectively). Given that these 2 segments account for about 5 million Canadian households, porbeagle shark listing and recovery could provide passive use value in the range of tens of millions of dollars annually to Canadians (note that these benefits were missed entirely with the standard 1-class conditional logit model because it did not capture relatively subtle respondent heterogeneity). The recommendation to list porbeagle shark as endangered was rejected (Government of Canada 2006) due to the potential costs ($0.8 million to $1.8 million in net present value) to the Nova Scotia fishing industry (DFO 2006). Results from this survey suggest that the benefits of porbeagle conservation to Canadian society as a whole in a single year could exceed the entire stream of commercial benefits accruing to fishers over a 20 yr time horizon.

Of the 4 other conservation program attributes, probability of program success was the most important for survey respondents. Mean WTP for a higher probability of program success ranged from $4.22 to $92.11 annually for best (100%) versus worst (50%) case scenarios. Most respondents were willing to pay more for conservation programs for which they thought conservation objectives would be achieved even when, as was the case with LC 2 for example, improvements in listing status and population abundance were themselves not significant.

Increases in population abundance and improvement in listing status coefficients were only significant in 4 of 9 segments each. Mean WTP for increases in population abundance, over the range of 50 to 200%, ranged from $0.64 to $13.31 annually (and was –$6.33 for Segment 9). For an improvement in listing status, mean WTP ranged from $0.97 to $26.45 annually. Many survey respondents did not differentiate between programs that improved listing status or population abundance, at least across this range of improvements. They were concerned not so much with the magnitude of outcomes or how those outcomes were defined as with knowing that efforts were being made to protect endangered species, a result consistent with those of Christie et al. (2006).

For the 7 segments with both significant funding mechanism and cost coefficients, WTP ranged from $1.07 to $132.87 annually for programs financed by a reallocation of existing tax dollars rather than new household taxes. Only LC 5 and LC 8 respondents were indifferent to financing options. The survey results suggest that the majority of households view their own income as more valuable than tax payments already in the hands of the government. This result is consistent with the results of Swallow & McGonagle (2006), who found that willingness to transfer public funds was over 3 times as great as WTP for land conservation programs funded by tax increases. Bergstrom et al. (2004) also found substantially higher WTP for tax payment reallocations relative to special new taxes for groundwater protection programs. While this is not surprising, Bergstrom et al. (2004) note that there could be potentially important welfare implications if tax reallocations were used to finance conservation efforts instead of new taxes, depending on the nature of respondent heterogeneity.

Sample segmentation

LC 1, the largest single segment (21.7% of the national sample) was characterized by positive and significant coefficients for all major survey attributes. Respondents in LC 1 tended to be much younger than average, with a slightly higher proportion of Quebec residents and French speakers relative to the overall sample. Respondents in this 'young and free-spending' segment had relatively strong preferences for conservation programs targeting high-profile leatherback turtles, right whales, and Atlantic salmon. The probability of conservation program success — irrespective of species focus — was a major factor influencing the overall utility of respondents.

LC 2 respondents (17.3% of sample) did not exhibit significant preferences for conservation programs that improved listing status or increased population abundance. Atlantic salmon was the most preferred species, and the 2 other freshwater species, Atlantic whitefish and white sturgeon, were also preferred relative to any of the other marine species. Demographically, LC 2 respondents were more likely to be from the Atlantic provinces (and less likely to be from the Prairies) than average, and were older and had higher than average income. The Atlantic salmon fishing dummy was large, positive, and significant, signifying that LC 2 members likely held a mix of non-extractive use (sport fishing) and passive use values for Atlantic salmon. Another distinguishing feature of LC 2 was the large and negative coefficient for the 'none' option. Members of LC 2, 'unconditional SARA supporters,' were willing to support even poor-performing SARA conservation programs targeting unpopular species rather than see government take no conservation action.

Respondents in LC 3 (12.5% of the sample) exhibited positive and significant preferences for all survey attributes except improvement in listing status. This segment was somewhat younger than average, with patterns of preferences similar to LC 1. Implicit prices in this 'young and frugal' segment were, however, lower than those in LC 1. Leatherback turtle and right whale were the most preferred species.

In LC 4 (12.4% of the sample), all survey attribute coefficients were significant but there were no significant demographic covariates. The preferred species of LC 4 respondents were the high-profile trio of Atlantic salmon, right whale, and leatherback turtle. The 'none' option for LC 4 was large, positive, and significant. Given the relatively large magnitude of that coefficient, LC 4 respondents could be considered 'conditional supporters' of SARA conservation programs. The incremental value of a total conservation package would need to surpass a non-trivial threshold before a representative respondent in LC 4 would be willing to support and help pay for SARA conservation initiatives.

LC 5 (11.1% of the national sample) respondents were characterized by strong preferences for right whale and leatherback turtle, and by the lack of significant coefficients for other conservation program attributes. The 'none' option was large, negative and significant. That is, LC 5 respondents tended to view any conservation program as preferred to a lack of action. The other distinguishing feature of this LC was the large, highly significant coefficient for the SARA expertise dummy variable, signifying that they were substantially more familiar with SARA than the general populace. Despite clear species preferences, higher than average knowledge about species at risk, and a strong desire to take some conservation action, respondents in LC 5 appear to have been unwilling or unable to make trade-offs between the different attributes of the conservation programs. This suggests that LC 5 members may have 'lexicographic preferences.' That is, people knowledgeable about SARA may believe that each of the species in the survey has a right to be protected irrespective of its utility for humans or the costs of protecting it. Spash & Hanley (1995) note that

> if lexicographic preferences are found to exist amongst a significant proportion of the population, the use of CBA [cost-benefit analysis] would be questionable. CBA is founded upon the concept of compensating for welfare losses… (p. 192)

Given that LC 5 constitutes 11.1% of the national sample, simply assuming that mean WTP is $0 for these 'non-utilitarian SARA supporters' because the cost coefficient is insignificant, may result in a substantial under-emphasis of the importance of SARA conservation to the Canadian public.

Respondents in LC 6 (7.5% of the national sample), like people in LC 2, exhibited strong preferences for conservation programs targeting Atlantic salmon and other freshwater species. Members of this 'freshwater sport fisher' group were significantly older than average, more likely than average to be Atlantic salmon fishers, and more likely to be French speakers. Unlike LC 2 respondents, who were unconditional SARA supporters, LC 6 respondents needed the incremental value of the total conservation package to surpass a threshold before they would support it. The combination of strong preferences for conservation programs targeting Atlantic salmon and the threshold suggests that LC 6 members may derive proportionally higher benefits from sport fishing (or options for fishing in the future) and lower benefits from passive use, relative to LC 2 members. Note that respondents from LC1 and LC3, who were significantly younger than average, exhibited relatively high passive use values for marine icon species, while respondents from LC2 and LC6, who were significantly older than average, exhibited higher WTP for species that did have some potential for recreational use.

LC 7 members comprised 6.0% of the national sample and were characterized by their very modest WTP for SARA conservation programs. This segment is also notable for having white sturgeon, a western Canadian fish, as its most preferred species. All conservation program coefficients are significant but there is a relatively high threshold to exceed before LC 7 members would be willing to support SARA conservation initiatives. Members of LC 7, 'marginal SARA supporters,' tend to be younger than average, English speaking, and more likely than average to live in central and western Canada (and less likely to live in Quebec).

LC 8 was another small group, 5.8% of the sample. The most distinctive feature of LC 8 members was their unwillingness to support SARA conservation programs. While they had distinct species preferences, none of the other conservation program attributes were significant except for the cost coefficient. The coefficient for the 'none' option was large and positive, indicating that gaining support for almost any SARA conservation program would be difficult for these 'SARA skeptics.' Demographically, there were more LC 8 respondents from British Columbia than average, and respondents within this segment had a significantly lower level of SARA expertise than average. Although rurality and survey response time were not significant in aggregate for this survey (Table 1), LC 8 members were more likely to reside in remote rural regions and were survey 'speeders', completing this complex survey relatively quickly compared to other respondents.

Finally, LC 9 (5.7% of the national sample) is characterized by somewhat unusual species preferences, the anomalous significant negative coefficient for an increase in the population abundance of endangered species, and by the very large, positive, and significant coefficients for program funding mechanism and the 'none' option. These 'no new tax advocates,' who had significantly higher income than average, did not seem to care what sort of conservation programs were implemented, so long as they were funded by a reallocation of existing taxes rather than new taxes.

Geographic scope of analysis

The interests of regional stakeholders often carry considerable weight in listing or resource allocation decisions regarding aquatic species at risk (e.g. Government of Canada 2006). The implicit assumption is that people who do not live in close geographic proximity to the endangered species do not value them. While the region of residence covariate was significant in this analysis (Wald = 65.9, $p < 0.001$), there are no clear patterns of regional preferences for endangered aquatic species that emerge from the data. A significantly higher proportion of Atlantic Canadians than average hold strong preferences for Atlantic salmon in LC 2, but LC 2 members also hold relatively strong preferences for white sturgeon, a western species. Significantly more LC 7 members, who were more likely to be from central and western Canada, indicated that white sturgeon is their most preferred species. Atlantic Canadians, however, are neither less nor more likely than average to be LC 7 members. The second to fourth most preferred species for LC 7 members are all from the Atlantic coast. Other than in LC 2 and LC 7, there are no individually significant coefficients for the region covariate.

These results clearly demonstrate that survey respondents from across Canada hold preferences such that they derive substantial passive use benefits (and likely non-extractive use and/or option values in the case of LC 2 and LC 6) from conservation programs targeting regional aquatic species at risk. An important implication of this finding is that, even for relatively low-profile regional aquatic species, passive use benefits outside the geographic range of species occurrence need to be considered by the Canadian government if it is to fulfill its legal obligations when making SARA listing decisions and to improve the economic efficiency of resource allocation decisions.

This is obviously a complicating factor for economic analyses dealing with SARA listing and recovery planning, and also has important implications regarding the role of, and cooperation between, multiple levels of government in SARA recovery planning and implementation. As Hein et al. (2006) emphasize, nature conservation is a cultural ecosystem service that is most valuable at the national and international scale. It is not reasonable to expect local or regional governance organizations to make decisions in the broad interest of society, protecting ecosystem services that provide few local benefits but impose substantial costs on local residents and businesses. Instead, national institutions need to take responsibility in order to match ecological and institutional scale (i.e. ensuring the proper 'scope of governance') when the overall well-being of a country's citizens are impacted or when international agreements may be needed to protect species that provide substantial benefits beyond national borders (Rudd et al. 2003, Hein et al. 2006).

CONCLUSIONS

The results of this survey provide valuable insights into how Canadians value aquatic species at risk and how values differ or (more correctly) are quite similar across the nation. An important finding of this research is that citizens from across Canada, including interior regions far from the coasts, derive economic benefits from the conservation of regional species at risk occurring on Canada's coasts. This implies that the geographic scope for future cost-benefit analyses of listing proposals should be expanded beyond the regions in which the species at risk actually occurs. Although further work is needed to quantify net welfare gains from specific SARA initiatives, national passive use benefits arising due to endangered species listing and recovery will likely run in the tens of millions of dollars annually for relatively low-profile fish species and into the hundreds of millions of dollars annually for high-profile species such as Atlantic salmon.

Mooers et al. (2007) recommended that SARA listing analyses quantify the full costs of extinction and the full benefits of recovery in order to enable fair comparisons against the costs of legal protection. Besides simply meeting legal obligations, it will be economically prudent from a societal perspective to invest substantial resources in SARA conservation and recovery initiatives that provide important public benefits for the citizens of Canada. Conversely, a failure to invest in the conservation and recovery of aquatic species at risk will impose substantial economic costs on Canadian society as a whole due to lost passive use benefits to citizens across the country.

Acknowledgements. M.A.R. is supported, in part, by the Canada Research Chairs Program. Survey design and data collection was undertaken while M.A.R. was employed as an economist with the Department of Fisheries and Oceans (DFO) Policy Branch, Maritimes Region. Thanks to DFO colleagues A. McPherson and S. Khwaja for helping to secure internal DFO funding for the survey, B. Charlton for providing informatics support, and F. Scattalon (Director General, DFO Maritimes) for kindly transferring DFO software licenses to Memorial University to facilitate the analysis.

LITERATURE CITED

Alvarez RM, Sherman RP, VanBeselaere C (2003) Subject acquisition for web-based surveys. Polit Anal 11:23–43

Bergstrom JC, Boyle KJ, Yabe M (2004) Trading taxes vs. paying taxes to value and finance public environmental goods. Environ Resour Econ 28:533–549

Birol E, Karousakis K, Koundouri P (2006) Using a choice experiment to account for preference heterogeneity in wetland attributes: the case of Cheimaditida wetland in Greece. Ecol Econ 60:145–156

Boxall PC, Adamowicz WL (2002) Understanding heterogeneous preferences in random utility models: a latent class approach. Environ Resour Econ 23:421–446

Carson RT, Mitchell RC, Hanemann M, Kopp RJ, Presser S, Ruud PA (2003) Contingent valuation and lost passive use: damages from the Exxon Valdez oil spill. Environ Resour Econ 25:257–286

Christie M, Hanley N, Warren J, Murphy K, Wright R, Hyde T (2006) Valuing the diversity of biodiversity. Ecol Econ 58: 304–317

Couper MP, Kapteyn A, Schonlau M, Winter J (2007) Noncoverage and nonresponse in an Internet survey. Soc Sci Res 36:131–148

DFO (Department of Fisheries and Oceans) (2006) Potential socio-economic implications of adding porbeagle shark to the list of wildlife species at risk in the Species at Risk Act (SARA). Fisheries and Oceans Canada, Dartmouth

Environment Canada (2003) Species at Risk Act: a guide. Environment Canada, Ottawa

Government of Canada (2006) Order giving notice of decisions not to add certain species to the List of Endangered Species. Can Gaz 140(Part II):1127–1131

Hanley N, Mourato S, Wright RE (2001) Choice modelling approaches: a superior alternative for environmental valuation? J Econ Surv 15:435–462

Hein L, van Koppen K, de Groot RS, van Ireland EC (2006) Spatial scales, stakeholders and the valuation of ecosystem services. Ecol Econ 57:209–228

Hu W, Hunnemeyer A, Veeman M, Adamowicz W, Srivastava L (2004) Trading off health, environmental and genetic modification attributes in food. Eur Rev Agric Econ 31:389–408

Hu W, Veeman M, Adamowicz W, Gao G (2006) Consumers' food choices with voluntary access to genetic modification information. Can J Agric Econ 54:585–604

Kotchen MJ, Reiling SD (2000) Environmental attitudes, motivations, and contingent valuation of nonuse values: a case study involving endangered species. Ecol Econ 32:93–107

Loomis JB, White DS (1996) Economic benefits of rare and endangered species: summary and meta-analysis. Ecol Econ 18:197–206

Martín-Lopéz B, Montes C, Benayas J (2008) Economic valuation of biodiversity conservation: the meaning of numbers. Conserv Biol 22:624–635

McFadden D (1974) Conditional logit analysis of qualitative choice behavior. In: Zarembka P (ed) Frontiers in Econometrics. Academic Press, New York, p 105–142

Milon JW, Scrogin D (2006) Latent preferences and valuation of wetland ecosystem restoration. Ecol Econ 56: 162–175

Mooers AO, Prugh LR, Festa-Bianchet M, Hutchings JA (2007) Biases in legal listing under Canadian endangered species legislation. Conserv Biol 21:572–575

Ojea E, Loureiro ML (2007) Altruistic, egoistic and biospheric values in willingness to pay (WTP) for wildlife. Ecol Econ 63:807–814

Pearce D (1998) Cost-benefit analysis and environmental policy. Oxf Rev Econ Policy 14:84–100

Pearce C, Moran D (1994) The economic value of biodiversity. Earthscan, London

Rudd MA, Tupper MH, Folmer H, van Kooten GC (2003) Policy analysis for tropical marine reserves: directions and challenges. Fish Fish 4:65–85

Spash CL, Hanley N (1995) Preferences, information and biodiversity preservation. Ecol Econ 12:191–208

Statistics Canada (2004) Postal code conversion file (PCCF), reference guide. Statistics Canada, Ottawa

Statistics Canada (2008) Canadian Internet use survey. The Daily (12 June 2008), Statistics Canada, Ottawa. www.statcan.ca/Daily/English/080612/d080612.pdf

Stevens TH, Echeverria J, Glass RJ, Hager T, More TA (1991) Measuring the existence value of wildlife: What do CVM estimates really show? Land Econ 67:390–400

Swallow SK, McGonagle MP (2006) Public funding of environmental amenities: Contingent choices using new taxes or existing revenues for coastal land conservation. Land Econ 82:56–67

TBS (Treasury Board Secretariat) (2007) Canadian cost-benefit analysis guide: regulatory proposals. Treasury Board Secretariat, Ottawa

Tisdell C, Wilson C, Nantha HS (2005) Policies for saving a rare Australian glider: economics and ecology. Biol Conserv 123:237–248

Train KE (2003) Discrete choice methods with simulation. Cambridge University Press, Cambridge

Venter O, Brodeur NN, Nemiroff L, Belland B, Dolinsek IJ, Grant JWA (2006) Threats to endangered species in Canada. Bioscience 56:903–910

Vermunt JK, Magidson J (2005) Technical guide for Latent GOLD Choice 4.0: basic and advanced. Statistical Innovations Inc., Belmont, MA

Zhang Y, Pang S, Wang Y (2001) Orthogonal arrays obtained by generalized Hadamard product. Discrete Math 238: 151–170

Editorial responsibility: Clement Tisdell, St. Lucia, Queensland, Australia

Submitted: May 30, 2008 Accepted: October 8, 2008
Proofs received from author(s): January 13, 2009