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Research article

A comparison of regional and national values for recovering threatened and endangered marine species in the United States☆

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ABSTRACT

It is generally acknowledged that willingness-to-pay (WTP) estimates for environmental goods exhibit some degree of spatial variation. In a policy context, spatial variation in threatened and endangered species values is important to understand, as the benefit stream from policies affecting threatened and endangered species may vary locally, regionally, or among certain population segments. In this paper we present WTP estimates for eight different threatened and endangered marine species estimated from a stated preference choice experiment. WTP is estimated at two different spatial scales: (a) a random sample of over 5000 U.S. households and (b) geographically embedded samples (relative to the U.S. household sample) of nine U.S. Census regions. We conduct region-to-region and region-to-nation statistical comparisons to determine whether species values differ among regions and between each region and the entire U.S. Our results show limited spatial variation between national values and values estimated from regionally embedded samples, and differences are only found for three of the eight species. More variation exists between regions, and for all species there is a significant difference in at least one region-to-region comparison. Given that policy analyses involving threatened and endangered marine species can often be regional in scope (e.g., ecosystem management) or may disparately affect different regions, our results should be of high interest to the marine management community.

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1. Introduction

In the field of non-market valuation, stated preference techniques like contingent valuation and stated preference choice experiments currently provide the only means to estimate non-consumptive use and non-use economic values for public goods such as threatened, endangered, or at-risk (TER) species. For these species, non-consumptive use value refers to the economic benefits individuals may derive from viewing, photographing, or learning about the species in the wild. Non-use value refers to the benefit individuals may derive from a species even if they never see or interact with it. Types of species-related non-use values can include the benefits derived from preserving the species for future generations or preserving the species now for future use (referred to as bequest and option value, respectively), as well as the benefits derived simply from knowing that the species exists (referred to as existence value). For brevity, in this paper we refer to economic benefit measures that reflect non-consumptive use and non-use collectively as ‘non-consumptive values’.

These benefit measures can be used in analytical and policy contexts by agencies charged with evaluating the costs and benefits of regulatory actions (Lipton et al., 2014). In the U.S. for example, non-consumptive values may be used in designating critical habitat for species listed under the Endangered Species Act (ESA) and in evaluating species recovery actions (Congressional Research Service, 2003). In Canada non-consumptive values can be used in determining whether to list a species under the Species At Risk Act (SARA), the Canadian counterpart to the U.S. ESA, as the Act requires the government to “*assess regulatory and non-regulatory options to maximize net benefits to society as a whole*” in the listing decision process (Rudd, 2009). Aside from the analyses related to

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species listings, non-consumptive values can be used in natural resource damage assessment cases and in fulfilling the directives of management paradigms such as ecosystem-based management, which calls for the evaluation of the full suite of ecosystem impacts when considering alternative policies (Lipton et al., 2014). Sanchirico et al. (2013) illustrate the importance of this in their examination of economic efficiency under modeling scenarios that include the economic benefits of recovering Steller sea lions, an endangered marine mammal.

Although the past two decades have seen substantial growth of non-market valuation research related to environmental amenities (Kling et al., 2012), including studies focused specifically on TER species, economic benefit information associated with TER marine species has been emphasized as a commonly missing but critical piece of information with respect to ecosystem management (Millennium Ecosystem Assessment, 2005). Over thirty published studies have measured the economic benefits of enhancing, protecting, or preserving TER marine species, but most have valued large or charismatic species such as whales, seals and sea lions, and sea turtles (see Lew, 2015). Several studies include iconic or high profile salmonid species, but few estimates exist for lesser known marine species or marine plants. Some of these studies are summarized in one (or more) of three species valuation meta-analyses (Loomis and White, 1996; Richardson and Loomis, 2009; Martin-Lopez et al., 2008) which, though fairly comprehensive of the published literature at that time, do not include values from a number of more recent studies on TER marine species (see Rudd, 2009; Lew et al., 2010; Ojea and Loureiro, 2010; Boxall et al., 2012; and Wallmo and Lew, 2012 for examples).

Non-consumptive values for TER species are generally expressed in terms of willingness-to-pay (WTP) for some level of improvement in the species population or to prevent extinction. For TER marine species, WTP ranges up to $256 for improving the status of the Beluga whale (Boxall et al., 2012), with estimates for most marine species falling between $10 and $100[1] (Lew, 2015). Comparing WTP values among studies to determine whether one species is more economically valuable than another, though potentially useful, is typically infeasible because of variation among studies[2] (Wallmo and Lew, 2012). Even within a study, WTP for a single species may vary based on issues such as respondent heterogeneity or spatial variation (Kaul et al., 2013). The latter is illustrated in Giraud and Valcic (2004), where geographically embedded samples are used to estimate WTP for recovering the endangered Steller sea lion. Their results showed considerable variation in WTP depending on whether the spatial sampling scale was local (Alaska boroughs), state (Alaska), or national (U.S.).

It is generally acknowledged that WTP estimated from stated preference techniques are often spatially heterogeneous (Johnston et al., 2015). Though the treatment of spatial variation has taken several approaches, the majority of research involves the premise of distance decay, in which WTP for an environmental good is assumed to diminish as distance between the individual and the good increases. Previous research has shown evidence of a distance decay effect for goods including National Parks, habitat protection, and river water quality improvements (Bateman and Langford, 1997; Georgiou et al., 2000; Hanley et al., 2003), though many of these reflect use values (e.g., values derived from actively using the resource). Other research involving non-use values (e.g., existence or bequest values) for the Great Barrier Reef have shown no evidence of distance decay when analyzed at a national scale (Rolfe and Windle, 2012). Some authors have suggested that for goods for which non-use values likely dominate, such as TER species values, there is no reason to expect a distance decay effect (Hanley et al., 2003). In an explicit test for a distance decay effect in TER species values, Loomis (2000) examined WTP for preserving the Mexican spotted owl and 62 other threatened and endangered species found near the states of Arizona, Colorado, Utah, and New Mexico in the U.S. He found that beyond 1500 miles of the spotted owl habitat household WTP is very low; however, for households up to 2500 miles away WTP for protecting the 62 other species were about 40% of local household values. In the same study, WTP for protecting the California spotted owl were substantial at a distance of 1000 miles from the species habitat.

Spatial variation for TER species has also been examined in the context of WTP hot/cold spots, or WTP patchiness. Fundamentally, hot spot analysis characterizes spatial clusters of high (hot) and low (cold) values, defining regions of high density separated by regions of low density of a given phenomenon (Nelson and Boots, 2008). Differences between hot (cold) clusters and the surrounding values are tested to determine whether the spatial clustering pattern is statistically different than one of random chance (Johnston et al., 2015). The analysis can be conducted at varying spatial scales. In the only research to date on hot/cold spots for TER marine species, Johnston et al. (2015) find that the number of cold spots for the Upper Willamette River Chinook salmon and the Puget Sound Chinook salmon varies from zero at small scales to over 80 at a spatial scale of 1170 km. The authors find a similar pattern for hot spots for both salmon and six other TER marine species. Notably, the authors find no evidence of distance decay in values for any of the TER marine species included in the study (Johnston et al., 2015).

A third context for examining spatial variation includes the use of geographically embedded samples. To date two studies have examined WTP for TER marine species in this context. In a study focused on Steller sea lion preservation, Giraud and Valcic (2004) found that non consumptive values for protecting the species, found in waters off the coasts of Alaska, British Columbia, and the West Coast of the U.S., were larger as the geographic scale of the sample increased. Specifically, WTP estimates from a sample of U.S. households were highest, followed by WTP estimates from an embedded sample of Alaska-only households, followed by WTP estimates from an embedded sample of households in Alaskan Boroughs containing Steller sea lion critical habitat. In contrast, Wallmo and Lew (2015) found no differences in WTP estimated from a sample of U.S. households and an embedded sample of U.S. west coast households for recovering eight different TER marine species, including species found only in rivers in southern California (southern California steelhead *Oncorhynchus mykiss*) to species found worldwide (Humpback whale *Megaptera novaeangliae*).

In a policy context, spatial variation in TER marine species values is important to understand, as “using national values may result in an incomplete analysis when populations local to the resource face a disproportionate cost/benefit from the policy” (Giraud and Valcic, 2004). In this paper we present values for eight different TER marine species including the Hawksbill sea turtle Eretmochelys imbricata, Southern resident killer whale *Orcinus orca*, Humpback whale Megaptera novaeangliae, Southern California steelhead *Oncorhynchus mykiss*, Central California coast Coho salmon *Oncorhynchus kisutch*, Black abalone Haliotis cracherodii, Elkhorn coral Acropora palmata, and Johnson's seagrass Halophila johnsonii. We

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[1] Values reported in 2013 U.S. dollars. All values converted using consumer price index and annual foreign currency conversion rates.

[2] Valuation studies often differ in the sampling unit (generally either household or individual), geographic scope of the sample (local, regional, or national level sample), payment frequencies used in valuation questions (one-time payment, annual, other frequency), size and type of species-level or population-level change (e.g., doubling the population size, preventing extinction, reducing the risk of extinction), valuation model specification, and quantity and quality of information provided to respondents, which may bias respondents' willingness to pay (Hoehn and Randall, 2002; Brouwer, 2000).

Table 1
Species in the stated preference choice experiment survey.

Common name	ESA status	Geographic range
Hawksbill sea turtle	Endangered	Atlantic, Pacific, Indian Oceans and Caribbean Sea
Southern resident killer whale	Endangered	Off the California, Oregon, Washington, and southern British Columbia coasts
Humpback whale	Endangered	Worldwide
Johnson's seagrass	Threatened	Small stretch of coastal lagoons in southeastern Florida
Central California coast coho salmon	Threatened	Tributary rivers and streams of northern and central California
Southern California steelhead	Endangered	Tributary rivers and streams of central California to northern Mexico
Elkhorn coral	Threatened	Shallow waters throughout the Caribbean Sea
Black abalone	Endangered	Shoreline of northern California to Mexico

estimate WTP at two different spatial scales: (a) a random sample of over 5000 U.S. households and (b) geographically embedded samples (relative to the U.S. household sample) of nine U.S. Census regions. We then compare WTP across regions for each of the eight species to determine whether species values are statistically different among households in different regions of the U.S. We then compare species values in each region with the national value to examine statistical differences between regional- and national-level values. Our paper makes an important contribution to the TER species valuation literature as, to our knowledge, it is only the third paper to formally compare TER marine species values using geographically embedded samples and the first to do so with a large number of species (eight) with considerably different geographic ranges (Table 1) and nine embedded regional samples. In addition, our presentation and inter-region comparison of eight species may improve the precision of policy analyses that involve TER marine species, as these can often be regional in scope (e.g., ecosystem management) or may disparately affect different regions.

2. Methods

A stated preference choice experiment (SPCE) (Adamowicz et al., 1998) was conducted to collect preference data for recovering the eight TER marine species listed above. Stated preference choice experiments, grounded in Lancastrian consumer theory (Lancaster, 1966), assume a good can be described in terms of its attributes. Attributes are assumed separable and are associated with a range of levels (generally set by the researcher). Experimental design plans are used to generate different combinations of attributes and levels that describe an alternative or option. In a SPCE survey, respondents are generally provided with information about the good and its associated attributes and then shown a series of choice-task questions, each consisting of two or more options. Respondents are asked to select their most preferred (and sometimes least preferred) option from a set. Data on respondent choices are then modeled using a random utility maximization (RUM) framework (McFadden, 1973), enabling WTP calculations for individual attributes or policy scenarios. A large literature exists on the use of SPCE for valuing environmental amenities, with detailed expositions on underlying theory, survey design, experimental design, and choice data analysis found in Louviere et al. (2000) and Hanley et al. (2001).

Our SPCE survey was developed over a three-year period that included input from scientists who study each species in the survey, a series of four focus groups, and nine one-on-one cognitive interview sessions. An experimental design was used to block the survey was into sub-versions that contained a subset of three of the eight species, which focus group input suggested to be the maximum number of species (and associated information and questions) that could be cognitively digested by respondents in a single survey. Focus groups and cognitive interviews were also used to assess the information in the survey instrument and ensure that (a) the quantity and quality of species information provided in the survey was similar among all species; (b) the language used to describe each species and its population status was clear and concise, and (c) the survey instrument was neutral in tone and content to minimize biasing respondents' preferences, and (d) the survey questions were clearly written and easy to understand. Finally, focus groups and interviews were used to ensure that respondents understood the choice-task questions and to help elucidate their decision-making process when they considered the options presented in each choice task.

The final survey instrument consisted of four sections: Section 1 provided general information concerning threatened and endangered species in the U.S. and the laws that protect them. Section 2 provided information about three of the eight TER marine species. Section 3 described additional species-specific protection actions, beyond the current set of protection actions, that if undertaken would improve the ESA listing status of the species. Section 4 consisted of three multi-attribute SPCE questions. The attributes were the ESA listing status for each of three species (species 1, species 2, and species 3) 50 years in the future and household cost, described in terms of a combination of increased taxes and costs of goods and services affected by the additional protection actions. The ESA listing status attribute could be one of three values (endangered, threatened, or recovered), and the household cost attribute had 6 cost levels (Table 2). In each SPCE question, respondents were asked to choose their most and least preferred options from a choice set consisting of the status quo (e.g., do nothing additional for no extra cost) and two options that improved the ESA listing status of one or more species at an additional household cost (Fig. 1). Options for the choice task questions were generated from a statistical experimental design plan that accounted for main effects and maximized a D-efficiency criterion (Louviere et al., 2000). The design plan generated 432 different survey versions, each containing three of the eight species.

The survey was implemented in October and November of 2010 by Knowledge Networks (now GfK Market Research) utilizing a random sample of their RDD[3]-recruited web-enabled panel of U.S. households. A modified Dillman et al. (2009) approach was used to field 16,359 surveys to randomly selected panel respondents across the U.S. Reminder emails were sent approximately one week after the initial contact, and a final reminder email was sent on November 19, 2010. A total of 10,637 surveys were completed, resulting in a completion rate of 65%. Analyses in this paper are based on a subset of this total (5061) due to issues related to experimental design.[4]

SPCE responses were analyzed using RUM-based discrete choice

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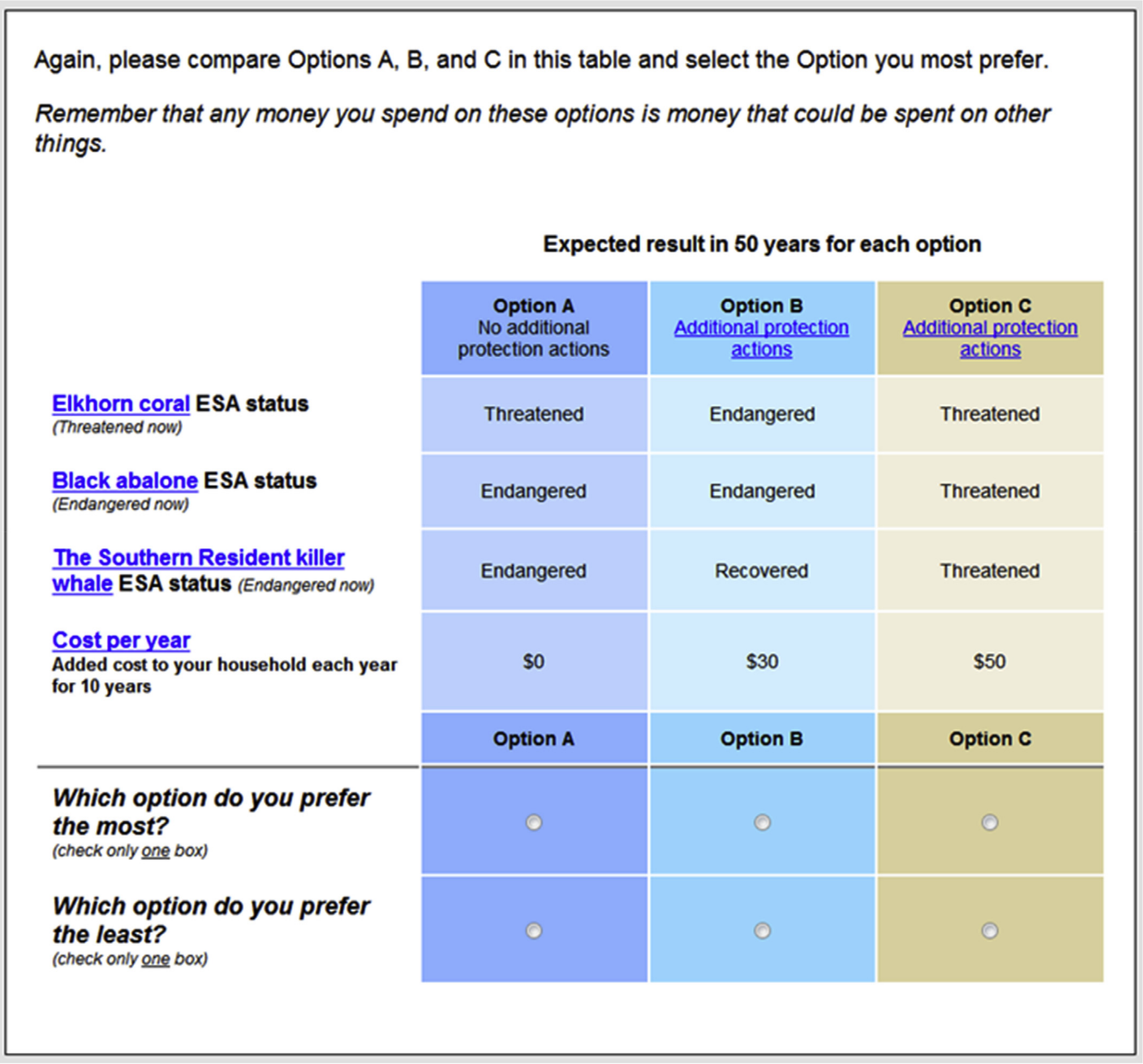
[3] Knowledge Networks employed random-digit-dialing recruitment methods to construct the national panel used in this research.

[4] A number of survey versions generated from the experimental design were devoted specifically to theoretical and methodological tests. These surveys contained differences in attributes and/or attribute levels and are therefore analyzed separately from the survey responses used in this paper.

Table 2
Experimental design attributes and levels.

Choice experiment attributes[a]	Levels
Hawksbill sea turtle	Endangered, threatened, recovered
Southern resident killer whale	Endangered, threatened, recovered
Humpback whale	Endangered, threatened, recovered
Johnson's seagrass	Threatened, recovered
Central California coast coho salmon	Threatened, recovered
Southern California steelhead	Endangered, threatened, recovered
Elkhorn coral	Threatened, recovered
Black abalone	Endangered, threatened, recovered
Cost (payment per household per year for 10 years)	\$10, \$20, \$30, \$50, \$60, \$100

[a] The experimental design was used to block survey instruments using groups of 3 species per survey.



Again, please compare Options A, B, and C in this table and select the Option you most prefer.

Remember that any money you spend on these options is money that could be spent on other things.

Expected result in 50 years for each option

	Option A No additional protection actions	**Option B** Additional protection actions	**Option C** Additional protection actions
Elkhorn coral ESA status *(Threatened now)*	Threatened	Endangered	Threatened
Black abalone ESA status *(Endangered now)*	Endangered	Endangered	Threatened
The Southern Resident killer whale ESA status *(Endangered now)*	Endangered	Recovered	Threatened
Cost per year **Added cost to your household each year for 10 years**	\$0	\$30	\$50
	Option A	**Option B**	**Option C**
Which option do you prefer the most? *(check only one box)*	○	○	○
Which option do you prefer the least? *(check only one box)*	○	○	○

Fig. 1. Stated preference choice experiment question.

statistical models. We specify utility (U) associated with a choice option as the sum of a systematic, known component (V) and a random component (ε). The utility respondent i receives from option j is expressed as

$$U_{ij} = V_{ij} + \varepsilon_{ij}, \tag{1}$$

where U_{ij} is the utility that i associates with j, V_{ij} is the quantifiable, known portion of utility, and ε_{ij} is the random, unobservable effects associated with option j for respondent i. The utility of option j is assumed to depend upon the ESA-status level of each of the species and the annual household cost. Assuming linear utility, as is common, the systematic component of utility V_{ij} is then

$$V_{ij} = \boldsymbol{\beta} \cdot X_{ij}, \tag{2}$$

where X_{ij} is a vector of the ESA-status levels for each species under option j and $\boldsymbol{\beta}$ is the vector of attribute coefficients. Thus, the utility function can be expressed as

$$U_{ij} = \boldsymbol{\beta} \cdot X_{ij} + \varepsilon_{ij}. \tag{3}$$

Assuming individuals maximize utility, individual i will choose option j if the utility of j is greater than the utility derived from any other option,

$$U_{ij} \geq max\{U_{i1} \ldots\ldots\ldots\ldots U_{iJ}\}. \tag{4}$$

To maximize the amount of information generated from each choice task and increase efficiency, in this application we asked respondents to indicate their most and least preferred alternative, thus providing a full ranking of the three alternatives. This can be expressed as

$$U_{ir_{i1}} > U_{ir_{i2}} > U_{ir_{i3}}, \tag{5}$$

where r_{i1} denotes the alternative that received the first (most preferred) ranking by individual i, r_{i2} denotes the second most preferred alternative, and r_{i3} the least preferred alternative. Assuming that the error terms follow a type I extreme value distribution the probability of observing a particular ranking by the ith individual, $\mathbf{r}_i$ ($\mathbf{r}_i = \{\mathrm{r}_{i1}, \mathrm{r}_{i2}, \mathrm{r}_{i3}\}$), is

$$Pr[r_i] = Pr\left[U_{ir_{i1}} > U_{ir_{i2}} > \ldots > U_{ir_{iJ}}\right] = \prod_{j=1}^{J-1} \frac{\exp\left(V_{ir_{ij}}\right)}{\sum_{l=j}^{J} \exp\left(V_{ir_{il}}\right)}. \tag{6}$$

In this application we assume that the species parameters are distributed continuously over the population instead of being fixed, and estimate a rank-ordered random parameters logit model (see Lew et al., 2010 for further details on this model specification). This specification incorporates respondent heterogeneity through the estimation of a distribution of species parameters. Full rank-ordering is obtained by allowing respondents to indicate their most and least preferred options in each choice-task question. Equation (6) was estimated in GAUSS using simulated maximum likelihood techniques.

WTP for species recovery was calculated over the distribution of species parameters using a simulation-based estimation procedure, following standard formulas for the measurement of compensating variation (Small and Rosen, 1981). Ninety-five percent confidence intervals were calculated following Krinsky and Robb (1986).

Rank ordered random parameters logit models and WTP estimates with 95% confidence intervals were calculated for the national sample and for nine regions defined by the U.S. Census:

- New England (NE): Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
- Mid-Atlantic (MA): New Jersey, New York, Pennsylvania
- East North Central (ENC): Indiana, Illinois, Michigan, Ohio, Wisconsin
- West North Central (WNC): Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota
- South Atlantic (SA): Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia
- East South Central (ESC): Alabama, Kentucky, Mississippi, Tennessee
- West South Central (WSC): Arkansas, Louisiana, Oklahoma, Texas
- Mountain (MT): Arizona, Colorado, Idaho, New Mexico, Montana, Utah, Nevada, Wyoming
- Pacific (PAC): Alaska, California, Hawaii, Oregon, Washington

To formally test for WTP differences between regions, and for differences between a regional (geographically embedded) and national sample, we used a method of convolutions approach described in Poe et al. (2005). This approach is also used to conduct comparisons between WTP differences for each pair of species in the same region (and nationally) to determine whether WTP is significantly higher (lower) for certain species.

3. Results

Respondent demographics for the national sample and the regionally embedded samples were fairly similar. The median age category (45–54) was the same for the national sample and all regionally embedded samples, as was the median education category (some college but less than a Bachelor's degree). Median annual income category varied slightly among regions, the lowest ($40K–$49,999) being in the WSC. For most of the regions, including the ENC, WNC, SA, ESC, MT, PAC, and the national sample, the median annual income category was $50K–$59,999. For the MA region the median annual income category was $60K–$74,999. Mean household size for the national samples was 2.76, and ranged from a minimum of 2.66 for MA to 2.94 for WSC. The percentage of male respondents was fairly close to 50% for all regions and the national sample, ranging from 49.5 for the national sample to 55.5 for NE.

Parameter estimates from the RUM models are shown in Table 3. In the table, REC indicates the parameter for recovering the species, and THR indicates the parameter for improving the species ESA status from endangered to threatened. At the time of the survey if a species ESA status was threatened that species will only have a REC parameter. Models from all samples (the national and the nine embedded samples) have three common results: (1) the positive sign and statistical significance of all of the REC species parameters, suggesting that recovering species is utility enhancing; (2) the statistically insignificant THR Elkhorn coral parameter, suggesting that improving Elkhorn coral from endangered to threatened does not affect utility; and (3) the negative and significant cost parameter, which is expected from theory. In terms of THR species parameter significance, there are differences between the models. In the national sample down-listing a species from endangered to threatened was utility enhancing for all applicable species (i.e. a species with an 'Endangered' ESA status) with the exception of Elkhorn coral. For the following regional samples down-listing is utility enhancing: Hawksbill sea turtle in the ENC, and SA samples; Southern California steelhead in the ENC, SA, and PAC models; and Southern resident killer whale in the ENC, WNC, MA, and MT models. The THR species parameters for all other samples are

Table 3
Rank-ordered random parameters logit model parameter estimates from national sample and regional embedded samples.

Parameter	National (n = 5,061)	NE (n = 229)	MA (n = 637)	ENC (n = 875)	WNC (n = 436)	SA (n = 845)	ESC (n = 231)	WSC (n = 515)	MT (n = 398)	PAC (n = 895)
REC Johnson's seagrass	0.5630*	0.7325*	0.7002*	0.5843*	0.6299*	0.6622*	0.6849*	0.6324*	0.7288*	0.5274*
REC Central CA coast coho salmon	0.6563*	0.8734*	0.7222*	0.6644*	0.7053*	0.7135*	0.6604*	0.5724*	0.9269*	0.7692*
REC Humpback whale	0.7831*	1.2512*	1.0405*	0.7901*	1.0025*	0.8747*	0.9832*	0.8235*	1.0987*	0.7992*
THR Elkhorn coral	0.0357	−0.1145	0.0527	0.1419	−0.0247	−0.0556	−0.0560	0.0813	0.1597	0.0246
REC Elkhorn coral	0.9059*	1.6316*	1.1162*	0.8289*	0.9613*	0.9823*	1.2333*	1.0001*	0.9710*	1.0119*
THR Hawksbill sea turtle	0.1412*	0.0189	0.1159	0.1975*	0.1221	0.2300*	0.1598	0.04715	0.1736	0.1131
REC Hawksbill sea turtle	1.0356*	1.4919*	1.1821*	1.1993*	1.2695*	1.1428*	1.2228*	0.9557*	1.3566*	1.1701*
THR Black abalone	0.0747*	0.4179	0.0876	0.0805	0.0882	−0.0004	0.1058	0.2104	0.1291	0.1072
REC Black abalone	0.8691*	1.3118*	1.0755*	0.9102*	1.1566*	0.8853*	1.0851*	0.7328*	1.3036*	0.9731*
THR Southern CA steelhead	0.1759*	0.3231	0.1194	0.1722*	0.1202	0.2201*	0.3062	0.2766	0.1794	0.2613*
REC Southern CA steelhead	0.8254*	0.8907*	0.9074*	0.8292*	1.1351*	0.9672*	0.9618*	0.7753*	1.1029*	0.8933*
THR Southern resident killer whale	0.1044*	0.5406	0.2131*	0.1696*	0.3532*	−0.0846	0.2424	0.0010	0.3544*	−0.0011
REC Southern resident killer whale	1.034*	1.5417*	1.0513*	0.9750*	1.3945*	1.4021*	1.2632*	1.2206*	1.0992*	1.1757*
Cost	−0.0257*	−0.0300*	−0.0266*	−0.0304*	−0.0324*	−0.0285*	−0.0326*	−0.0279*	−0.0351*	−0.0262*

NE = New England; MA = Mid-Atlantic; ENC = East North Central; WNC = West North Central; SA = South Atlantic; ESC = East South Central; WSC = West South Central; MT = Mountain; PAC = Pacific.
*Parameter significant ($p < 0.05$).

statistically insignificant.

Mean WTP for recovering a species, reported as the annual value a household is willing to pay for ten years, and ninety-five percent confidence intervals are shown in Table 4. As a majority (80%) of the THR species parameters were not significant in the regional models, WTP for down-listing a species is not reported in Table 4, and all comparative analyses are conducted using WTP for species recovery. The highest mean WTP values from the national sample are for recovering the Hawksbill sea turtle ($85.95) and the Southern resident killer whale ($84.38), and the lowest mean WTP from the national sample is $43.83 for recovering Johnson's seagrass. We note mean WTP for down-listing species with a significant THR parameter in the national model is $51.74 (Hawksbill sea turtle), $39.48 (Black abalone), $45.81 (Southern California steelhead), and $48.36 (Southern resident killer whale). Willingness-to-pay estimated from the regional embedded samples ranges from a low of $38.51 (Johnson's seagrass) for the ENC to $121.05 (Southern resident killer whale) for the NE sample.

Table 5 presents the results of the method of convolutions tests to determine whether species values are significantly different between (a) the national sample and geographically embedded samples (national-region$_X$) and (b) any two regions, X and Y (region$_X$-region$_Y$). Seventy-two national-region$_X$ comparisons were conducted (8 species values, 9 regions) and 288 region$_X$-region$_Y$ comparisons were conducted (8 species values, 36 region pairs). Values from three embedded samples – the ENC, NE, and WSC – differed from the national sample, suggesting that most species values from geographically embedded samples are not statistically different from national sample values. Embedded sample values were different from national sample values for Elkhorn coral, the Hawksbill sea turtle, and the Southern resident killer whale. These differences represent about 5.5% of the total number of national-region$_X$ comparisons. About 8% of the region$_X$-region$_Y$ comparisons showed statistically significant differences in species values, and there was no species for which at least one region$_X$-region$_Y$ comparison was not significant. Similar to results of the national-region$_X$ comparisons, Elkhorn coral had the largest number of differences in region$_X$-region$_Y$, comparisons. Southern California steelhead values were different only between the ENC and PAC regions, and Johnsons' seagrass values were different between the ENC and MA regions. Values for the Central California coast coho salmon, Hawksbill sea turtle, and Southern resident killer each differed in two region$_X$-region$_Y$ comparisons, and Humpback whale and Black abalone values differed in three region$_X$-region$_Y$ comparisons.[5]

Table 6 presents the results from a method of convolutions test of whether two species in the same region have statistically different WTP values for recovery. This test of paired species WTP values is conducted on the national sample, as well as on each of the regional embedded samples. Results at the national level suggest that, in general, species values are significantly different from each other. Only four recovery values are not statistically different (out of a total of 28 paired WTP differences). Elkhorn coral recovery values are similar statistically to the values for black abalone and Southern California steelhead. The hawksbill sea turtle and Southern resident killer whale recovery values, though statistically higher than the other six species, are not significantly different from each other, and black abalone and Southern California steelhead are also statistically similar. At the national level these results may be evidence of stronger preferences for certain species over others. However, as Table 6 shows, at the regional level there are more statistically similar recovery values. The region with the lowest number of insignificant pairs was the PAC, where 11 of the 28 paired WTP differences were not statistically different. In the ESC nearly all WTP differences (26 of 28 pairs) were statistically similar.

4. Discussion

Species recovery values derived from a national sample of U.S. households ranged from approximately $86 (mean annual WTP per

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[5] To examine what factors might contribute to region$_X$-region$_Y$ differences we conducted a logistic regression, where the dependent variable took on the value of 1 if the species value between region$_X$ and region$_Y$ was significant and a zero otherwise. Independent variables including respondent education, gender, age, household income, marital status, perceived household impact of additional recovery actions, and score on the New Ecological Paradigm scale (Dunlap et al., 2000) also entered the model as 1's and 0's, with 1 indicating a significant difference between region$_X$ and region$_Y$ for that variable. The only statistically significant variable in the regression was marital status. There are a number of limitations to this analysis, including the small sample (288) and the binary nature of both the dependent and independent variables in the model. We present the analysis as a footnote as it was not intended to contribute to the primary objectives of the paper and was exploratory in nature.

Table 4
Willingness-to-pay for recovering species from national sample and regional embedded samples.

Species	National	NE	MA	ENC	WNC	SA	ESC	WSC	MT	PAC
Johnson's seagrass	$43.83	$49.50	$52.75	$38.51	$39.14	$46.51	$42.31	$45.45	$41.66	$40.31
	(40.67–46.87)	(26.63–75.95)	(41.91–63.92)	(31.42–45.44)	(27.98–50.21)	(37.57–55.24)	(24.91–61.02)	(34.34–56.84)	(30.14–52.85)	(32.37–48.07)
Central CA coast coho salmon	$51.06	$59.29	$54.18	$43.58	$43.64	$49.92	$40.37	$40.88	$52.90	$58.67
	(47.59–54.67)	(37.71–87.99)	(43.54–66.36)	(35.88–52.06)	(32.49–56.28)	(41.51–59.49)	(20.96–63.75)	(29.76–53.00)	(41.45–66.21)	(50.50–68.18)
Humpback whale	$60.98	$85.02	$78.57	$52.08	$62.45	$61.50	$61.31	$59.23	$62.98	$61.21
	(57.47–64.52)	(35.35–136.65)	(64.40–93.65)	(43.70–60.75)	(48.09–77.62)	(51.55–71.56)	(36.10–90.10)	(46.23–72.62)	(50.60–75.71)	(51.82–70.70)
Elkhorn coral	$71.78	$106.36	$85.56	$59.01	$58.45	$66.72	$73.72	$74.31	$59.65	$78.04
	(67.30–76.23)	(74.79–146.60)	(69.40–103.47)	(49.13–69.66)	(42.23–75.11)	(55.55–78.36)	(50.97–101.20)	(58.23–91.78)	(46.10–73.64)	(67.36–89.73)
Hawksbill sea turtle	$85.95	$85.95	$93.53	$85.55	$82.79	$88.42	$80.86	$70.40	$82.74	$93.90
	(81.27–90.20)	(62.90–155.60)	(78.73–109.83)	(75.05–96.80)	(63.51–103.09)	(75.93–101.96)	(42.74–122.22)	(56.35–85.00)	(66.01–100.73)	(83.00–105.53)
Black abalone	$70.50	$102.34	$83.72	$62.20	$74.02	$61.67	$68.85	$59.73	$77.71	$78.13
	(66.19–74.58)	(53.09–162.37)	(68.09–100.54)	(51.09–73.51)	(55.04–94.87)	(48.77–74.69)	(31.40–110.56)	(44.56–76.87)	(58.39–98.22)	(66.87–90.49)
Southern CA steelhead	$71.06	$101.23	$72.69	$60.17	$74.20	$75.49	$69.26	$65.56	$68.21	$78.17
	(66.29–75.96)	(32.52–124.09)	(54.23–90.65)	(48.60–70.97)	(54.46–94.39)	(61.93–87.77)	(32.38–115.05)	(44.50–86.46)	(50.27–86.23)	(64.38–91.51)
Southern resident killer whale	$84.38	$121.05	$86.59	$69.45	$97.20	$95.11	$84.39	$87.53	$72.62	$89.46
	(79.15–89.69)	(53.51–196.42)	(64.91–109.28)	(57.77–81.82)	(75.44–121.62)	(80.55–110.25)	(22.91–151.21)	(69.23–107.46)	(55.14–91.40)	(72.67–106.33)

NE = New England; MA = Mid-Atlantic; ENC = East North Central; WNC = West North Central; SA = South Atlantic; ESC = East South Central; WSC = West South Central; MT = Mountain; PAC = Pacific.

Table 5
Statistically significant differences[a] in species values between pairs of geographic samples.

Species	National-region$_X$	Region$_X$-region$_Y$
Johnson's seagrass	NONE	MA-ENC
Central CA coast coho salmon	NONE	PAC-ENC PAC-WSC
Humpback whale	NONE	MA-ENC MA-SA MA-PAC
Elkhorn coral	NATIONAL-NE NATIONAL-ENC	NE-ENC NE-WNC NE-SA NE-MT MA-ENC MA-WNC MA-MT PAC-ENC PAC-MT
Hawksbill sea turtle	NATIONAL-WSC	WSC-MA WSC-PAC
Black abalone	NONE	MA-ENC MA-SA MA-WSC
Southern CA steelhead	NONE	ENC-PAC
Southern resident killer whale	NATIONAL-ENC	ENC-WNC ENC-SA

[a] Difference between samples are significant ($p < 0.05$) if the method of convolutions interval does not contain zero.

household for a period of ten years) to recover the Hawksbill sea turtle to approximately $44 to recover Johnsons' seagrass. In the national sample, WTP for down-listing ranged from about $52 for the Hawksbill sea turtle to $39 for Black abalone. Though we do not explicitly test for scope sensitivity, the generally smaller (or insignificant) WTP values for down-listing species, relative to the estimated recovery values, suggests that respondents considered the magnitude of the species improvement when making decisions. In addition, the difference in recovery versus down-listing values may also be evidence that respondents understand risk and prefer to eliminate the possibility of species extinction rather than simply reduce it. For the regional samples, recovery values range from $121 in New England to recover the Southern resident killer whale to $38 in the East-North-Central region to recover Johnsons' seagrass. As an overarching result, our WTP values suggest that individuals derive positive economic benefits from non-consumptive use of TER species.

For the national sample and for most regional samples, recovery values were high for the Hawksbill sea turtle and the southern resident killer whale, and lower for Johnsons' seagrass and the Central California coast coho salmon. New England differed slightly in their higher values (>$100) for Elkhorn coral, Black abalone, Southern California steelhead, and Southern resident killer whale. We acknowledge that these ‘species preference ordering patterns''are speculative and have not been formally tested to determine whether different species have statistically different values, but suggest this as an important topic for further research.

A small percentage (<6%) of all national-region$_X$ comparisons were significant, and those that were involved only three species – the Hawksbill sea turtle, Southern resident killer whale, and Elkhorn coral. Results were similar for the region$_X$-region$_Y$ comparisons, as only 8% of these comparisons were significant and nearly 40% of those were for Elkhorn coral. Though New England generally had larger mean values than most regions for most species, only Elkhorn coral values were statistically larger. The two regions that might be described as the most atypical among all regions include the Mid-Atlantic and the East-North-Central, which had the largest number of regional differences, 11 and 10, respectively. The Mid-

Table 6
Statistically significant differences[a] in WTP for species recovery values.

	Hawksbill sea turtle	Southern resident killer whale	Humpback whale	Johnsons seagrass	Central California coast coho salmon	Southern California steelhead	Elkhorn coral	Black abalone
Hawksbill sea turtle		–	NAT, ENC, PAC, SA	NAT, ENC, MA, MT, NE, PAC, SA, WNC, WSC	NAT, ENC, MA, MT, PAC, SA, WNC, WSC	NAT, ENC	NAT, ENC, MT, SA	NAT, ENC, SA
Southern resident killer whale			NAT, ENC, PAC, SA, WNC, WSC	NAT, ENC, MA, MT, PAC, SA, WNC, WSC	NAT, ENC, MA, PAC, SA, WNC, WSC	NAT, SA	NAT, SA, WNC	NAT, SA, WSC
Humpback whale				NAT, ENC, MA, MT, PAC, SA, WNC	NAT, MA, WNC, WSC	NAT, PAC	NAT, PAC	NAT, PAC
Johnsons seagrass					NAT, PAC	NAT, ENC, MT, PAC, SA, WNC	NAT, ENC, MA, NE, PAC, SA, WSC	NAT, ENC, MA, MT, PAC, WNC
Central California coast coho salmon						NAT, ENC, PAC, SA, WNC, WSC	NAT, ENC, ESC, MA, NE, PAC, SA, WSC	NAT, ENC, MA, MT, PAC, WNC
Southern California steelhead							–	–
Elkhorn coral								–
Black abalone								

[a] The listing of a region or NAT (national) indicates that a significant difference exists between recovery values for two species at $p < 0.05$.

Atlantic differed significantly with at least one region for all species except the Central California coast coho salmon, Southern California steelhead, and Southern resident killer whale; the same is true for the East-North-Central region for all species except the Hawksbill sea turtle. These results suggest that for actions affecting some threatened and endangered marine species, the Mid-Atlantic and East-North-Central regions accrue different benefits than those accrued by other regions or the nation as a whole.

It is worth mentioning that Elkhorn coral had the largest amount of spatial variation in recovery values: there were recovery value differences between the national sample and two regions and nine region_X-region_Y comparisons. The high values for Elkhorn coral in New England, the Mid-Atlantic, and the Pacific regions are largely responsible for this result, though it is unclear why values in those regions are high. It may be that in these predominantly coastal regions healthy coral is perceived as an indicator of overall marine or ecosystem health and the value is reflecting something in addition to the species itself. It is also possible that, because Elkhorn coral was a species likely to be impacted by the Gulf Oil Spill (which had occurred just prior to the survey implementation), respondents from some coastal regions placed an atypically high value on recovering the species. These explanations are tentative and additional research would be needed to explicitly address the question of why spatial variation in WTP occurs in these regions. What our study results do suggest is that policy and management analyses focused on Elkhorn coral should pay attention to regional variation in recovery benefits.

The findings above concerning regional differences in WTP should warrant consideration in policy analyses. For example, though economic values cannot be used in the decision to list a species in the U.S., they can be used after a species is listed – primarily in critical habitat designation and the development and evaluation of recovery plans. Both of these are subject to regulatory analyses (e.g., Regulatory Impact Analyses), which require consideration of the costs and benefits of an action (see U.S. Executive Order 12866 for example). Often actions involving critical habitat designation and recovery planning are focused on a geographic region, and the use of regionally-specific cost and benefit estimates, if available, can potentially improve the precision of the analysis. Similar arguments can also be made for cases of natural resource damage assessments, which often require benefit and cost estimates associated with environmental damage or degradation in a specific geographic area. Additionally, as noted by Lew (2015), TER species values can be used as inputs into management frameworks such as ecosystem-based management (EBM) or coastal and marine spatial planning (CMSP) to provide a fuller accounting of the extent of the private and social benefits and costs associated with coastal and marine policies. As EBM and CSMP are often implemented at a regional or ecosystem scale, it is logical to input regionally-specific data into trade-off, benefit-cost, or other analyses undertaken as a part of these management approaches.

Our results support earlier work by Wallmo and Lew (2015); however they are dissimilar from those of Giraud and Valcic (2004). One reason for this difference may be related to scale. Giraud and Valcic (2004) compared Steller sea lion values derived from Alaska boroughs samples to values derived from state and national samples. Our analysis compared much broader multi-state regions. In addition, improving the Steller sea lion would likely have significant local impacts at the borough level whereas very few households in our survey (generally less than 6%) stated they would be extremely affected by additional recovery actions undertaken to recover a species. The differences between this and the Giraud-Valcic study, and the findings of Johnston et al. (2015), suggest that the effect of scale on spatial variation in WTP is an important area for future research.

There are a number of caveats to our study. First, the regional sample sizes were unequal and naturally much smaller than the national sample, resulting in large confidence intervals for the regional samples. It is difficult to say whether larger sample sizes in the regions would produce different end results. Another potential caveat is the fact that the study was implemented shortly after the Gulf Oil Spill occurred. Though we have not formally conducted tests to determine whether the spill influenced WTP values, evidence from other studies (Farrow et al., 2016) suggest that general attitudes towards protected species and the environment did not differ significantly before and after the event. A third caveat of the study is our choice of regional boundaries. We can speculate, particularly in light of Johnston et al. (2015), that regions defined by different boundaries (e.g., geographically larger or smaller, coastal or non-coastal, etc.) may produce different results – the question is empirical. What our findings do underscore, however, is that spatial variation in WTP does exist, and managers should be careful to match the appropriate benefit measure to the geographic management scale in regulatory and policy analyses.

5. Conclusions

Overall our study demonstrates that at both regional and national scales the U.S. public derives positive utility from recovering threatened and endangered marine species. In addition our results suggest that spatial variation in species values is fairly limited when comparing values across broad regional scales, and much of this variation is attributable to one species – Elkhorn coral. We also find evidence that, for five of the eight species in the study, nationally-derived value estimates are representative of regional preferences and vice-versa. Exceptions to this exist in some regions for the Hawksbill sea turtle, Southern resident killer whale, and Elkhorn coral. Given the recent attention to marine species declines (WWF, 2015) and the emphasis on regional management approaches, such as ecosystem-based management and coastal and marine spatial planning, information on the benefits of recovering threatened and endangered marine species – particularly at different spatial scales – can inform and potentially improve policy analyses.

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