Sea Duck Joint Venture
Annual Project Summary for Endorsed Projects
FY 2010 – (October 1, 2009 to September 30, 2010)

Project Title (SDJV Project #126): Refining marine contaminant studies of Pacific scoters: integrating analyses of distributions, diet, and condition

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Project Description

Effects of metals and organic contaminants on growth and reproduction are of high concern for many marine animals, especially for scoters and other species that often feed in heavily industrialized bays and estuaries. Of particular concern, Surf Scoters appear to accumulate appreciable levels of selenium and cadmium in some marine sites (Ohlendorf et al. 1986, Henny et al. 1991). Past studies of marine contaminant exposure of scoters have focused mainly on rates of uptake during brief periods in mid-winter, neglecting other periods and effects of seasonal movements and diet shifts. Such results indicate only that contaminant exposure varies among the few sites considered, and accordingly provide little guidance for managing scoter foraging habitats at broad spatial scales. To increase functional understanding of contaminant exposure in coastal habitats, our proposed studies contrast contaminant uptake between Surf and White-winged Scoters, taking into account new data on their movements, diet, and physiological condition. These new contaminant studies will complement our ongoing analyses of scoter energetics and foraging strategies, thereby expanding our efforts to address the SDJV priority to **identify and inventory important sea duck coastal habitats**.

At least three scenarios warrant more detailed analyses of contaminant accumulation by scoters in marine habitats. First, tens of thousands of scoters molt in the Puget Sound-Georgia Basin (PSGB), mainly in very high concentrations within urbanized sites. Scoters molting in these sites may accumulate substantial agricultural and industrial contaminants prior to the typical winter period considered in past studies. Second, late season foods of Surf Scoters are often of higher trophic status than bivalves, which may entail greater exposure of Surf Scoters to contaminants that increase with trophic level such as cadmium and organic pollutants (Muirhead and Furness 1988, Anderson et al. 2009). Past studies likely underrepresent Surf Scoter exposure to contaminants because they failed to analyze contaminant loads in spring subsequent to their shifts in diet to foods such as spawn of Pacific herring (*Clupea pallasii*). Third, seasonal shifts in diet of Surf Scoters appear to be the result of nutritional stress (Anderson and Lovvorn 2010), which may increase their susceptibility to contaminant exposure. In particular, exposure to some contaminants such as cadmium may exacerbate effects of food limitation on energy metabolism (Di Giulio and Scanlon 1985). However, relationships between contaminant loads and physiological condition of marine animals are not well understood.

Study area Our principal study sites for this work are the Fraser River Delta in the Strait of Georgia, BC, and Padilla Bay and Penn Cove in northern Puget Sound, Washington (Fig. 1). The Fraser River Delta and Padilla Bay are the dominant molting sites for scoters in the PSGB, with up to 10,000 scoters per year in each site (J. R. Evenson, unpubl. data). To evaluate consequences of molting at lower latitudes in heavily industrialized sites, we will compare contaminant levels of molting scoters in the Fraser River Delta/Padilla Bay versus in undeveloped sites in SE Alaska (Objective 1). Analyses of contaminant exposure relative to dietary shifts and nutritional condition will rely on scoter tissues sampled in Penn Cove (Objective 2) and Birch Bay (Objective 3), two of the most heavily-used wintering sites in Puget Sound.

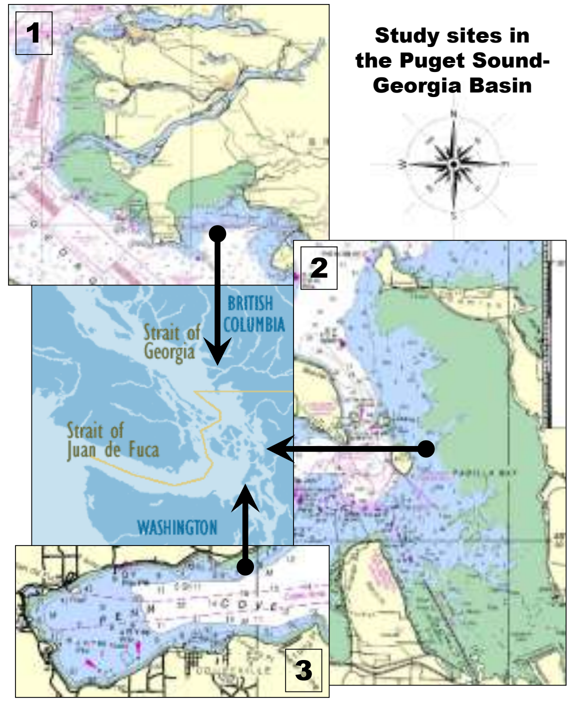

Figure 1. Principal study sites in the PSGB: (1) the Fraser River Delta in British Columbia; and (2) Padilla Bay and (3) Penn Cove in Washington.

Objectives

Our proposed studies contrast contaminant uptake of Surf and White-winged Scoters relative to differences in their seasonal movements and diets documented in our ongoing research. Specifically, our objectives include:

1. Contrast contaminant exposure of Surf versus White-winged Scoters in heavily industrialized molting sites in the PSGB. To this end, we will evaluate rates of metal uptake relative to:
   a. Variation in diet between scoter species documented in related studies; and
   b. Uptake rates documented for each scoter species during molt in non-industrialized sites in SE Alaska.
2. Evaluate whether contaminant exposure varies between Surf and White-winged Scoters relative to recently identified differences in their seasonal foraging strategies. In particular, we will quantify whether Surf Scoters accumulate greater contaminant loads as a result of their typical shifts in diet during spring to prey of higher trophic status. To this end, we will contrast uptake of metals between scoter species following a shift in diet to herring spawn by Surf but not White-winged Scoters in Birch Bay, WA.
3. Clarify the degree to which contaminant exposure affects physiological condition of Surf Scoters, including additive effects to food limitation. To this end, we will evaluate whether metals loads account for variation in condition among individual Surf Scoters in a site where the availability of key foods declines seasonally. We will focus on two sets of condition measures:
   a. Body mass and composition (total lipid, protein); and
   b. Nutritional condition as reflected in levels of plasma metabolites (triglycerides, butyrate, uric acid).

Preliminary Results

Contaminant analyses of scoter tissues Efforts thus far have focused mainly on developing protocols to assay scoter tissues for selenium and heavy metals in Marj Brooks' lab at Southern Illinois University (see Table 1 for tissues we have collected and their relation to our objectives). Analyses of these contaminants in scoter liver, kidney, and blood tissues were begun in September 2010 according to the following protocols. After microwave digestion (MARS System, CEM corporation) in 1:2 ratio of 18 MOhm water:nitric acid (Optima grade; vol:vol), tissues are being analyzed for selenium concentration using hydride generation on a flame atomic absorption spectrometer (Varian 240FS), for mercury using cold vapor generation (VGA 77, Varian corporation), for copper, cadmium, and zinc using graphite furnace atomic absorption spectrometry (AA240Z with zeeman correction, Varian corporation). For high tissue concentrations of zinc, we are replicating those analyses using flame spectrometry. Marj Brooks' lab observes full QA/QC protocols (APHA et al. 2005), including the use of an external quality check with bovine liver standard reference material (National Institute of Standards and Technology, SRM 1577c).

Table 1. Data collected during 2005–2006 and 2009, and analyses for which they will be used.

Data description	***Sample timing and size***	***Data use***
Scoter whole blood		Whole blood will be analyzed to contrast uptake of selenium and heavy metals between species and between industrialized (WA, BC) vs. undeveloped (AK) molt sites (Objective 1).
Padilla Bay, WA	Aug-Sep 2009 (12 SUSC)	
Fraser River Delta, BC	Aug-Sep 2009 (12 SUSC, 12 WWSC)	
SE Alaska	Aug-Sep 2009 (12 SUSC, 12 WWSC)	
Scoter liver and kidney samples		Used to evaluate exposure of Surf Scoters to metals and organic contaminants following their common seasonal shift in diet to herring spawn (Objective 2).
Birch Bay, WA	Dec 2005 (10 SUSC, 10 WWSC)	
	late Mar 2006 (10 SUSC, 10 WWSC)	
SE Alaska	May 2005/2006 (20 SUSC)	
Scoter liver and kidney samples		Used to assess whether contaminant exposure elevates effects of food limitation on Surf Scoter condition (Objective 3).
Penn Cove, WA	late Mar 2006 (10 SUSC)	

Project Status

Subsequent to successful funding of this project by SDJV, the principal investigators agreed that this contaminant research was sufficient to entail an MSc thesis. To this end, Marj Brooks recruited and will serve as primary supervisor for Jessi Hallman at Southern Illinois University. Completion of these studies as a graduate thesis slightly alters and extends our projected schedule, but will not meaningfully alter the scope of this research. In June 2010 we transferred about 250 samples of scoter livers, kidneys, and blood from Simon Fraser University and the University of Wyoming to Southern Illinois University. Marj and Jessi developed protocols for analyzing these tissues in August and September, and Jessi was formally enrolled as an MSc candidate in September. Jessi is currently developing a study plan and analyzing contaminants in scoter tissues. During 2010–2011 Jessi will visit principal field sites in the PSGB and possibly gather additional scoter tissues in conjunction with related field studies. We project that laboratory analyses of all scoter tissues will be completed by June 2011, Jessi will defend her thesis during July 2012, and all manuscripts will be submitted by September 2012.

Literature Cited

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