Sea Duck Joint Venture
Annual Project Summary for Endorsed Projects
FY 2005 – (October 1, 2004 to Sept 30, 2005)

Project Title (SDJV Project #47): Relationship of hepatic Selenium to pre-breeding nutrient reserves, reproductive status and deposition in eggs: a comparison of White-winged Scoters and Lesser Scaup

Principal Investigators:
Jean-Michel DeVink, University of Saskatchewan, 115 Perimeter Rd, Saskatoon, Saskatchewan, S7N 0X4, jean-michel.devink@ec.gc.ca
Dr. Stuart Slattery, Ducks Unlimited Canada, Institute for Wetland and Waterfowl Research, Box 1160, Stonewall, Manitoba, R0C 2Z0, s_slattery@ducks.ca
Dr. Bob Clark, Canadian Wildlife Service, 115 Perimeter Rd, Saskatoon, Saskatchewan, S7N 0X4, bob.clark@ec.gc.ca
Mark Wayland, Canadian Wildlife Service, 115 Perimeter Rd, Saskatoon, Saskatchewan, S7N 0X4, mark.wayland@ec.gc.ca

Project Description:

Based on breeding waterfowl surveys, Lesser Scaup (LESC) and White-winged scoters (WWSC) have both declined throughout the northern boreal forest with highly correlated population trends. Given the similar population fluctuations, it is plausible both taxa share common causes of decline. One of the hypotheses proposed for the decline of LESC is that increasing contaminants, particularly Selenium (Se), are affecting breeding populations, and so we are evaluating aspects of Se dynamics in both species. Specifically, we are evaluating the hypothesis that females with high body burdens do not deposit Se into eggs due to their reliance on exogenous nutrients for egg production.

Se is an essential micro-nutrient in vertebrates and is increasing in the environment from anthropogenic activities such as burning fossil fuels, agricultural irrigation, and ore smelting. However, since it was identified as the primary contaminant in the disease and die-off of waterbirds at Kesterson National Wildlife Refuge, wildlife toxicologists have been studying this element with greater interest. Reports indicate that, overall, seabirds carry heavier body burdens than similar non-marine species, and sea ducks are no exception. In birds, the most Se sensitive endpoint is embryonic development; Se is thought to be primarily deposited in the egg as part of amino-acids used in the production of proteins. The amount deposited in the egg will vary in relation to the concentration in food and endogenous nutrient reserves in the female, as well as the proportion of each used in egg formation. For example, individuals carrying heavy body burdens may not deposit significant amounts into eggs if dietary nutrients containing low concentrations of Se are used in egg production; conversely, a bird that accumulates endogenous nutrients containing high Se levels and subsequently uses these endogenous nutrients for egg production will deposit Se into its eggs. Therefore, it is difficult to extrapolate the endogenous selenium concentrations ([Se]):egg [Se] ratio among species that vary on the capital-income breeding energetics continuum.

In this study, we are testing our Se hypothesis by taking a multi-species approach of evaluating Se burdens in pre-breeding and early breeding female LESC and WWSC, as well as in their breeding ground prey and eggs/follicles. Again, as both species exhibit correlated population trends, a multi-species approach will provide a more rigorous test of the hypothesis assuming a common cause of decline. LESC were collected from three sites in the western boreal forest, while WWSC were collected from only one due to local densities. Livers and oviducal eggs/ovarian follicles are being analysed for Se, and we are using two analysis techniques, proximate and stable-isotope, to measure female reproductive energetics. Understanding the reproductive energetics is important to better understand the endogenous: egg Se ratio. Proximate analyses involve estimating whole carcass nutrient contents, using various extraction techniques, which are then correlated with estimates of the nutrients deposited into reproductive tissues. The stable-isotope technique uses element stable-isotope ratios, which vary geographically, to determine proportional origins of nutrients in tissues (e.g., egg nutrients are derived 40% from marine and 60% from freshwater sources).

Objectives:

The objectives of this study are:

1. To measure Se concentrations in various WWSC and LESC tissues.
2. To determine the liver:egg Se relationship in WWSC and LESC and compare these relationship to those reported for other avian species.
3. To determine if the liver:egg Se ratio fits with our model based on the estimated reproductive energetic strategy and the Se concentrations from endogenous and dietary sources.
4. To determine on a large scale using stable-isotopes (wintering grounds vs. breeding grounds) where Se is being acquired.

Preliminary Results

All tissue samples have been sent for Se analyses, however, we are still awaiting results from 50% of the samples, which include all scaup data. Based on our partial data set, we have found novel results from our contaminant and proximate nutrient analyses for scoters. As expected, there was a positive correlation between matched liver and developing follicle [Se] (figure 1), but similar to other studies of scoters, the matched liver:egg ratio of 14:1 (ug/g Se dw) we observed is much larger than that reported for most other waterbirds (approximately 2:1). We also analysed the contents of several pre-rapid-follicular-growth (pre-RFG) follicles for Se and also found a positive relationship with liver [Se], but that levels were an order of magnitude higher than in the RFG follicles (figure 2). As scoter follicles likely undergoe initial growth while birds are on wintering grounds, these may accumulate Se prior to development. When we then examined the relationship between follicle weight and [Se], we noticed that there is a non-linear negative relationship (figure 3). This supports the idea that nutrients deposited into follicles during growth have low Se levels and effectively dilute the initially high [Se]. Also, these findings suggest that nutrients for egg production are likely derived from breeding ground sources, as these would have lower Se levels than endogenous

nutrients. However, once all data are in hand we will use ANCOVA and model selection techniques to determine factors affecting egg [Se].

Prior to stable isotope analysis, reproductive energetics were primarily evaluated using proximate analyses of carcass composition, though accuracy of this technique has been questioned recently. We intend to compare proximate analysis with stable-isotope analysis of reproductive energetics in LESC and WWSC. After running proximate analyses on both species, we found that there was no relationship between our somatic protein index (protein index = breast and leg muscles, heart and gizzard) and reproductive protein (protein content of the oviduct and follicles and eggs layed) in LESC (figure 4a), but a weak decreasing relationship in WWSC (figure 5a). There were negative relationships between our somatic lipid index (lipid index = square root of abdominal fat) and reproductive lipids in both species, though stronger in WWSC (figure 4b, 5b). Indices were developed from measures taken during dissections and provided the highest correlation coefficient with nutrient estimates from our subsample of birds subjected to proximate analyses. All somatic nutrient estimates were corrected for size by regressing these values against PC1 score from head, tarsus, wing chord, and bird length measurements and using the residual values.

Our results for LESC proximate nutrient analyses corroborate previous studies, but those from WWSC conflict with the only report on the reproductive energetics of WWSC conducted at Redberry Lake, SK, which found no relationship between somatic and reproductive nutrients. These preliminary results of proximate nutrient analyses support our contaminants results by suggesting that endogenous protein reserves do not decrease while females are producing eggs, and so Se bound to amino acids are likely not deposited into eggs. Lipids, however, decrease during egg production and may be used in clutch formation. Stable-isotope results will provide further information to test these results.

Project Status

We anticipate attaining all objectives of this study as sample birds were collected in 2003 and 2004, and adequate funding was secured for necessary analyses. We have completed proximate nutrient analyses of all scaup and scoters, however, statistical analyses are not complete. We also are waiting for completion of 50% of the Se analyses from samples submitted to NWRC in September, 2004, which are currently being processed. Lipid, egg/follicle, prey samples, and feathers are presently being prepared for stable-isotope analyses. Once all data has been gathered, we will complete our analyses and manuscript publication in accordance with the proposed schedule.

We were able to reduce cost of liver and egg sample preparation and Se analysis by having JMD conduct most laboratory work. This resulted in a budget surplus of approximately 2700 USD from SDJV funds for this component of the study, which will be used to increase the number of scoter and scaup stable isotope samples analysed for this study, and to communicate results.

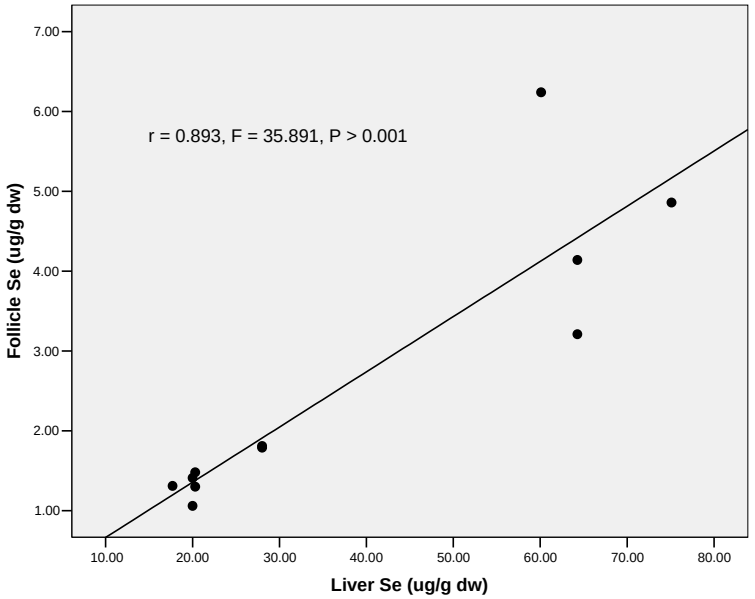


Figure 1. Correlation between liver and ovarian follicle selenium concentrations in WWSC collected from the Lower Mackenzie River Basin, NT.

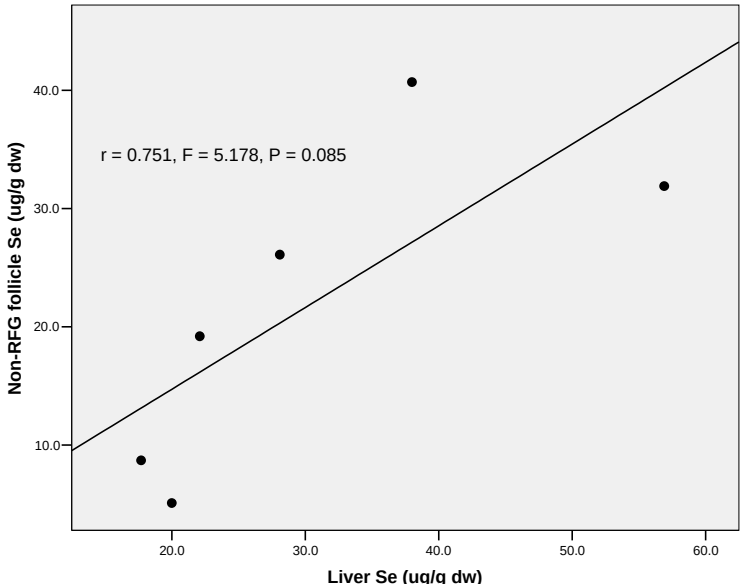


Figure 3. Correlation between liver and non-RFG ovarian follicle selenium from WWSC collected in 2004 from the Lower Mackenzie River Basin, NT.

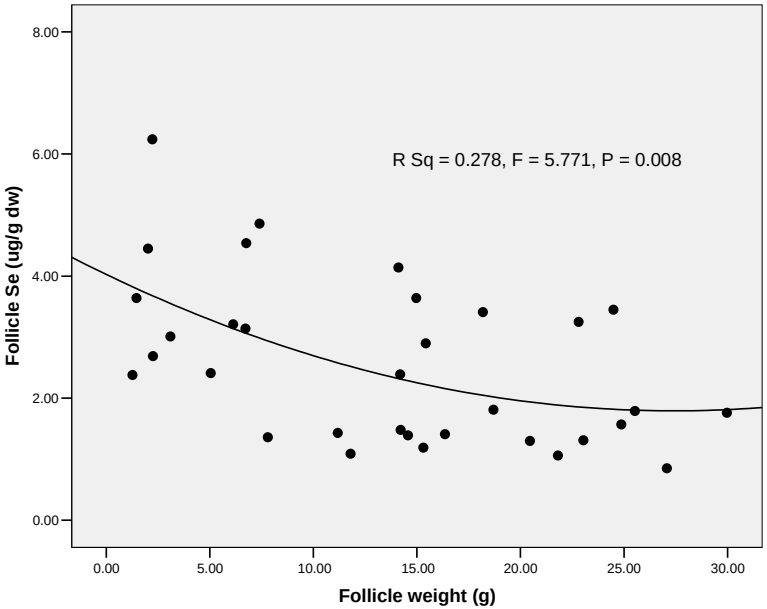
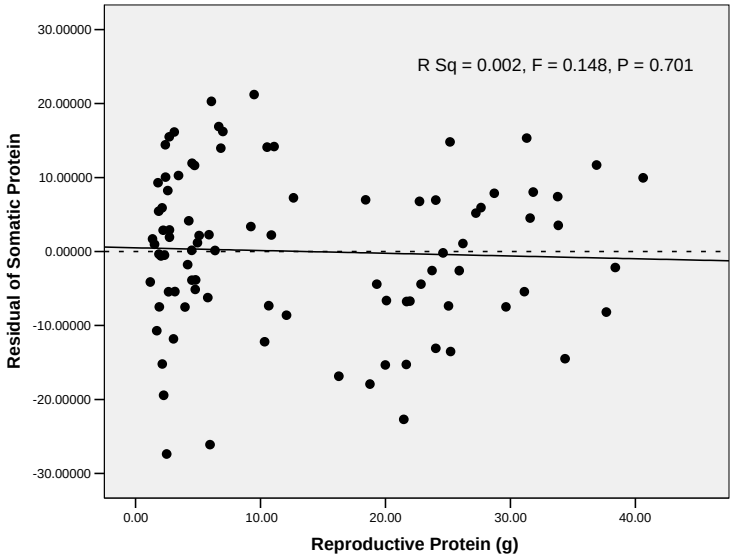


Figure 2. Regression of ovarian follicle weight and selenium concentration from WWSC collected from the Lower Mackenzie River Basin, NT.

a)



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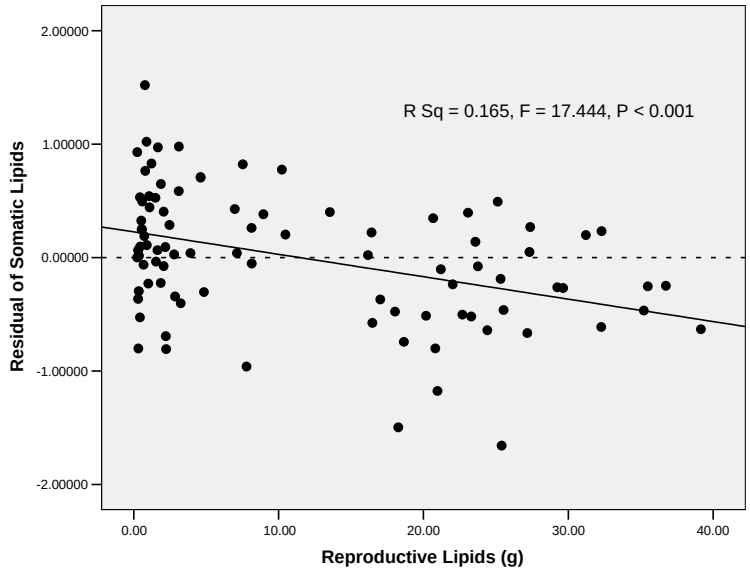
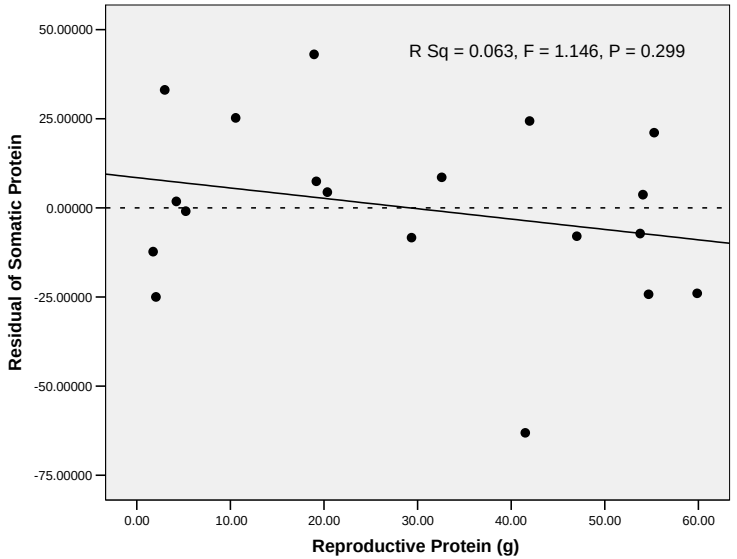


Figure 4. Regression of LESC a) reproductive protein and size corrected residuals of somatic protein index and b) reproductive lipids and size corrected residuals of somatic lipid index.

a)



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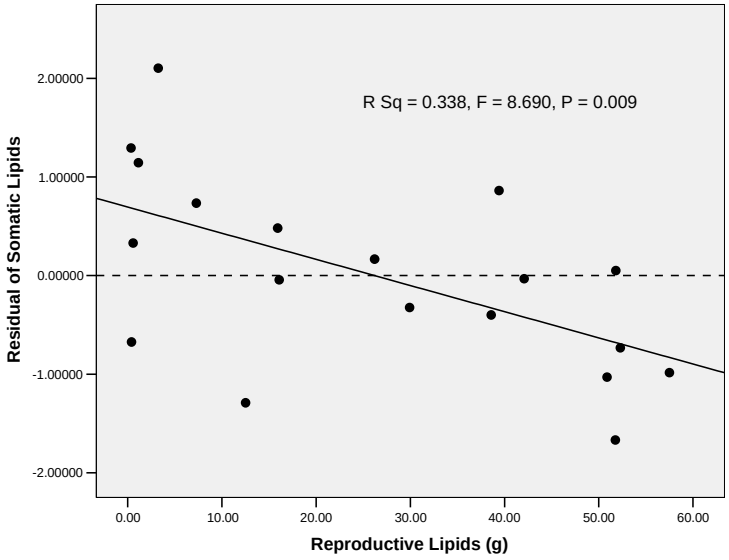

Figure 5. Regression of WWSC a) reproductive protein and size corrected residuals of somatic protein index and b) reproductive lipids and size corrected residuals of somatic lipid index.