LETTERS

Edited by **Jennifer Sills**

Selling First Nations down the river

OIL AND GAS interests and the government recently offered a First Nation in the Skeena River estuary (BC, Canada) $1 billion to consent to construction of a controversial terminal to load fossil fuels onto tankers (*1*). The proposal highlights a troubling blind spot in Canada's environmental decision-making. This gap could enable decisions that insufficiently consider risks to both environment and people. Science can help decrease these blind spots.

The second-largest salmon producer in Canada, the Skeena River has supported First Nation fisheries for 5 millennia (*2*). Its estuary is a nursery for hundreds of millions of young salmon annually as they graduate from freshwater to sea (*2*). It is also situated between fossil fuel reserves in interior Canada and ocean-access to Asian markets. Multinational companies have proposed pipelines to and terminals in the estuary, and are currently assessing the environmental impacts on constitutionally protected (*3*) aboriginal fisheries. Previous research indicates that industrialized estuaries depress salmon survival (*4*). Although terminal proponents and the government have recognized interests of First Nations from the estuary during environmental assessment, they have ignored interests of upriver First Nations who also harvest salmon (*5*).

Salmon migrate thousands of kilometers during their life. We have shown that the proposed development area supports particularly high abundances of juvenile salmon from more than 40 populations that are harvested in at least 10 First Nations territories throughout the Skeena watershed and beyond (*6*, *7*). This is twice the number of First Nations groups that industry proponents identified as needing to be consulted (*5*).

These data reveal a striking mismatch between the narrow consideration of aboriginal rights and environmental risks and the true scale of environmental connections, which needs to be addressed by the Canadian Environmental Assessment Agency (CEAA) and industrial proponents. The terminal application is being evaluated by CEAA without consideration of upriver First Nations (*5*). Moreover, despite the resounding rejection of the $1 billion by the estuary First Nation due to environmental and cultural concerns, the government has ratified fiscal agreements with terminal proponents (*8*). The Skeena Watershed is united by salmon; First Nations throughout the watershed should be involved in decisions that could damage their fisheries.

Identifying the proper spatial scale for environmental decision-making is a fundamental challenge for environmental policy and ethics. Whether it is migratory animals like salmon that transmit impacts, hydroelectric dams that deprive downstream farming communities of water (*9*), or carbon emissions from industrialized countries that raise ocean levels and threaten low-lying islands (*10*), decisions can impact distant ecosystems and people. Science can and should inform the scale at which environmental decision-makers weigh risks to the environment and human rights against potential economic benefits.

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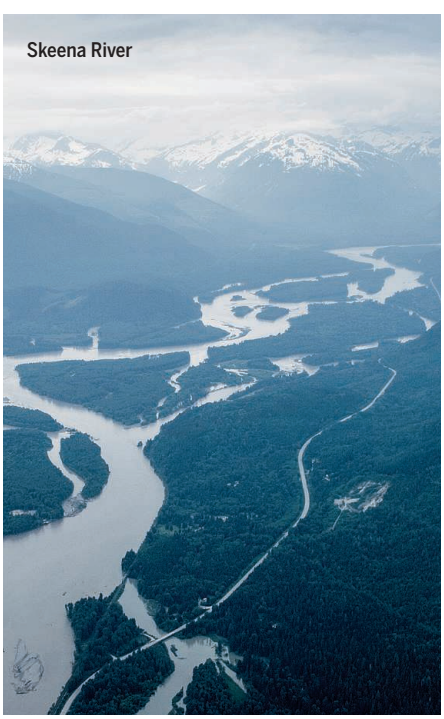
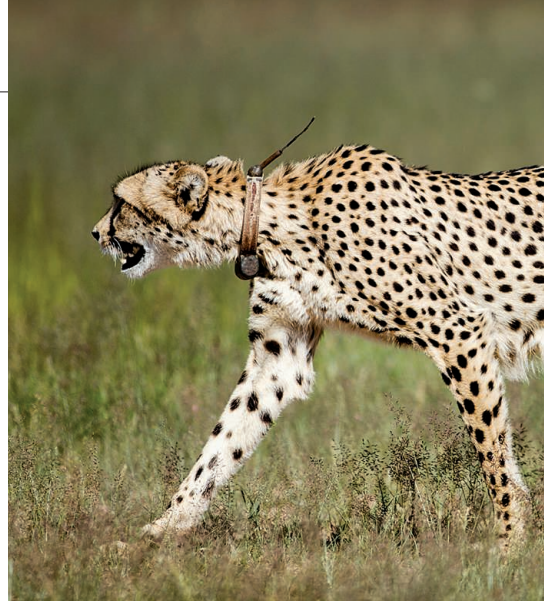


Skeena River



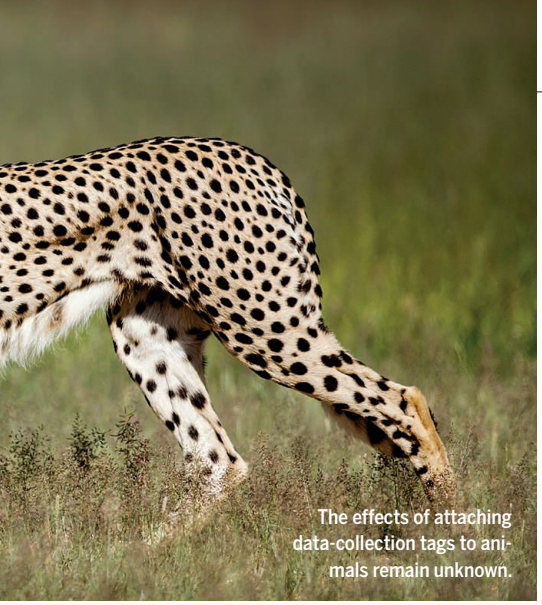
REFERENCES

1. Lax Kw'alaams Band, LNG Benefits (http://laxkwalaams.ca/wp-content/uploads/2015/04/Bulletin-2-Benefits-Summary-01054439.pdf).
2. A. S. Gottesfeld, K. A. Rabnett, *Skeena River Fish and Their Habitat* (Ecotrust, Portland, OR, 2008).
3. Government of Canada, Constitution Act, 1982, schedule B to the Canada Act 1982 (UK) c. 11, Section 35 (1982).
4. A. Magnusson, R. Hilborn, *Estuaries* **26**, 1035 (2003).
5. Stantec Consulting Ltd., *Pacific Northwest LNG Environmental Assessment Certificate Application* (Burnaby, BC, 2014).
6. C. Carr-Harris, A. S. Gottesfeld, J. W. Moore, *PLOS ONE* **10**, e0118988 (2015).
7. C. Carr-Harris, A. S. Gottesfeld, J. W. Moore, "Genetically-identified salmon from Flora Bank region, Skeena River estuary, 2013 and 2014" (http://moorelab.wix.com/moorelab#!flora-bank-salmon/cvyk).
8. Bill 30: Liquefied Natural Gas Project Agreements Act. (2015). 1st Reading July 21, 2015, 40th Parliament, 4th session. Retrieved from: www.leg.bc.ca/40th4th/1stread/gov30-1.htm.
9. E. P. Glenn, C. Lee, R. Felgar, S. Zengel, *Conserv. Biol.* **10**, 1175 (1995).
10. J. Barnett, W. N. Adger, *Clim. Change* **61**, 321 (2003).

Animal telemetry: Tagging effects

THE 12 JUNE Reviews by R. Kays *et al.* ("Terrestrial animal tracking as an eye on life and planet," p. 1222) and N. E. Hussey *et al.* ("Aquatic animal telemetry: A panoramic window into the underwater world," p. 1221) highlight some challenges to the future of terrestrial and aquatic telemetry studies, respectively, focusing on issues related to global collaboration and data sharing. Kays *et al.* also mention the need to continually improve animal-mounted sensors to minimize impacts of tags on animals. However, the gaps in our understanding of impacts associated with attaching instruments to animals are not given substantial consideration in either Review.

Potential impacts may be associated with capture/immobilization stress (*1*), increased drag (and its associated impacts on energy expenditure and locomotor performance)



The effects of attaching data-collection tags to animals remain unknown.

from external tags on aquatic and flying animals (*2*), behavioral modifications (*3*), and even environmental impacts such as biofouling (the accumulation of microorganisms or plants on wet surfaces) (*4*). The requirement for more studies assessing tagging impacts has been recognized for some time [e.g., (*5*)]. Some recent papers reported impacts ranging from negligible (*6*, *7*) to substantial (*8, 9*), but the paucity of such studies remains. In fact, in a review of papers reporting results from biologging deployments on free-ranging marine mammals (1965 to 2013; n = 620), I only found 14 papers explicitly aimed to quantify potential impacts associated with instrument deployments (*10*). The knowledge contributions of telemetry studies are undeniable and auspicious, but adequately measuring and minimizing possible negative instrument effects remain important challenges and should receive increased research interest.

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REFERENCES

1. A. M. M. Baylis *et al.*, *Mar. Mammal. Sci.* **31**, 322 (2015).
2. C. Tudorache *et al.*, *PLOS ONE* **9**, e112280 (2014).
3. J. M. van der Hoop *et al.*, *J. Exp. Biol.* **217**, 4229 (2014).
4. R. R. Reisinger *et al.*, *Polar Biol.* **33**, 561 (2010).
5. R. P. Wilson, C. R. McMahon, *Front. Ecol. Environ.* **4**, 147 (2006).
6. R. R. Reisinger *et al.*, *PLOS ONE* **9**, e111835 (2014).
7. Y. Kim *et al.*, *Mar. Ornithol.* **42**, 63 (2014).
8. S. P. Vandenabeele *et al.*, *Mar. Ecol. Prog. Ser.* **519**, 239 (2015).
9. A. L. Rasiulis *et al.*, *J. Wildl. Manage.* **78**, 953 (2014).
10. T. McIntyre, *Afr. J. Mar. Sci.* **36**, 409 (2014).

Animal telemetry: Follow the insects

UNDERSTANDING animal movements is crucial for ecology, evolution, and global change. Miniaturized tracking tags have created unprecedented opportunities for advancing knowledge on animal movements. R. Kays *et al.* ("Terrestrial animal tracking as an eye on life and planet," Review, 12 June, p. 1222) summarize breakthroughs with modern Global Positioning System (GPS) devices and suggest that GPS tracking with global communication functionality will allow monitoring of the planet and its ecosystem services. However, this approach is limited by its taxonomic focus on vertebrates (especially birds and mammals). Assuming a global estimate of 5 to 8 million species of insects and other arthropods on Earth (*1*, *2*), the tracking of even 15,000 bird and mammal species would only cover 0.2 to 0.3% of all terrestrial animal species on Earth.

Insects are the most species-rich and abundant terrestrial animals, and they play key roles in ecosystem services (e.g., pollination), food production (e.g., pests), and pathogen spread (e.g., insect-transmitted plant diseases). Conventional (battery-powered) radio tags have now become small enough to allow the telemetry of large insects (*3*), but modern GPS devices remain too heavy for automated, large-scale, and high-resolution insect tracking. The "eye on life and planet" with GPS tags will therefore be blind to the vast majority of animal movements on Earth.

Since only a tiny fraction of animal diversity can be tracked with GPS devices, renewed efforts and additional funding are needed for tracking insect movements across taxa and regions. Manual radio tracking, harmonic radar, and the development of automated tracking systems are crucial for quantifying insect movement at landscape scales (*3–5*), and aerial radio telemetry (*6*) as well as vertical-beam entomological and weather radars (*7–9*) can reveal regional- to continental-scale insect migrations. Monitoring our changing planet requires not only the tracking of vertebrates, but also the myriad movements of insects.

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REFERENCES

1. C. Mora, D. P. Tittensor, S. Adl, A. G. B. Simpson, B. Worm, *PLOS Biol* **9**, e1001127 (2011).
2. M. J. Caley, R. Fisher, K. Mengersen, *Trends Ecol. Evol.* **29**, 187 (2014).
3. W. D. Kissling, D. E. Pattemore, M. Hagen, *Biol. Rev.* **89**, 511 (2014).
4. R. Kays *et al.*, *Comput. J.* **54**, 1931 (2011).
5. J. L. Osborne *et al.*, *J. Appl. Ecol.* **36**, 519 (1999).
6. M. Wikelski *et al.*, *Biol. Lett.* **2**, 325 (2006).
7. J. W. Chapman, D. R. Reynolds, K. Wilson, *Ecol. Lett.* **18**, 287 (2015).
8. J. Shamoun-Baranes *et al.*, *Movement Ecol.* **2**, 9 (2014).
9. J. W. Chapman, V. A. Drake, D. R. Reynolds, *Annu. Rev. Entomol.* **56**, 337 (2011).