rainbow trout. In the years that followed, an increase in size of kokanee in the West Arm was mistakenly attributed (for a variety of reasons) to the introduction of the shrimp and, as a result, mysid shrimp was introduced to hundreds of lakes across North America (including Arrow Lakes) and Scandinavia. Although some are eaten by kokanee, the reality is that mysid shrimp compete with kokanee for zooplankton rather than provide a food source for them. Mysid shrimp are able to avoid predation by spending the day in deep, dark water. They migrate at night to the surface waters to feed on zooplankton, thus competing with kokanee for food. There were initial concerns that the restoration of nutrients would lead to significant increases in mysid shrimp populations that would out-compete the kokanee but this has not been the case.

WHAT IS THE DIFFERENCE BETWEEN NUTRIENTS AND POLLUTION?

When the lakes or reservoirs receive large amounts of nutrients from agricultural run-off, sewage plants or industrial effluents, the growth of algae is uncontrolled and can overwhelm the lake ecosystem. This would be pollution. The restoration of nutrients, in contrasts, adds a balance of nutrients over a wide area at specific times of the year, and the process and results are carefully monitored to ensure a healthy ecosystem.

DOES IT AFFECT MY SWIMMING AND SHOULD I WORRY ABOUT WATER QUALITY?

The Canadian Water Quality Guidelines for the Protection of Aquatic Life and the Protection of Drinking Water for Humans contain regulations for the amounts of nitrogen and phosphorus permitted in water. Nutrient concentrations during the NRP remain far lower than those permitted by such regulations.

DOES IT AFFECT HOW CLEAR THE WATER IS?

Biologists ensure that the Nutrient Restoration Program is balanced and that there is not an excess production of plankton. An increase in plankton will reduce the clarity of the water (because of light absorption and scattering) but, in general, water clarity in B.C. lakes are determined by particles naturally washed in, or by storms, wind and wave action. Secchi disc measurements (a patterned disc that is lowered into the water until it cannot be seen) are taken at all the monitoring sites and, typically, the water is clearer now than it was prior to when the dams were constructed. Secchi disk measurements range from 3 metres during the summer months to 15 metres during the late fall and winter months.

WILL THERE BE A TIME WHEN THE NRP IS NOT NEEDED?

In the late 1990s the level of nutrients added to Kootenay Lake was decreased to see if the lake had retained enough to maintain kokanee stocks. This was not the case and there was a subsequent decrease in phytoplankton densities and kokanee numbers. There are currently no plans to cease the program although biologists are always exploring new methods of dispersal to improve the efficiency of the nutrient up-take.

HOW MUCH DOES IT COST?

The total annual combined costs, including monitoring, for the Nutrient Restoration Program (for upper Arrow Lakes Reservoir and the north arm of Kootenay Lake), is approximately $1.79 million (this includes partnered and in-kind time). The south arm project costs approximately $700,000.

WHO PAYS?

The majority of the funds (over $1.1 million) come from BC Hydro through the Fish and Wildlife Compensation Program, Water License Requirements and in-kind support comes from the Ministry of Environment and FLNRO. The Columbia Power Corporation provides approximately $225,000 annually to assist with the implementation of the Nutrient Restoration Program in the upper Arrow Lakes Reservoir. Funding is provided by Arrow Lakes Power Corporation (ALPC) which owns the Arrow Lakes Generating Station. ALPC is jointly owned by Columbia Power Corporation and Columbia Basin Trust. Columbia Power Corporation manages the operations of the ALPC on behalf of the joint venture. The funding is being provided as a compensatory benefit for the operations of the Arrow Lakes Generating Station. South Arm nutrient additions are funded by the Kootenai Tribe of Idaho that receives funding from the Bonneville Power Administration, through the Northwest Power and Conservation Council's Columbia Basin Fish and Wildlife Program.

WHAT IS THE FWCP?

The Fish and Wildlife Compensation Program (FWCP) is a partnership between BC Hydro, the Province of B.C. and Fisheries and Oceans Canada to conserve and enhance fish, wildlife and their supporting habitats affected by the creation of BC Hydro owned and operated generation facilities in the Coastal, Columbia and Peace regions of British Columbia.

The FWCP is a partnership of:

BC hydro FOR GENERATIONS

British Columbia

Canada

Fisheries and Oceans Canada

Pêches et Océans Canada

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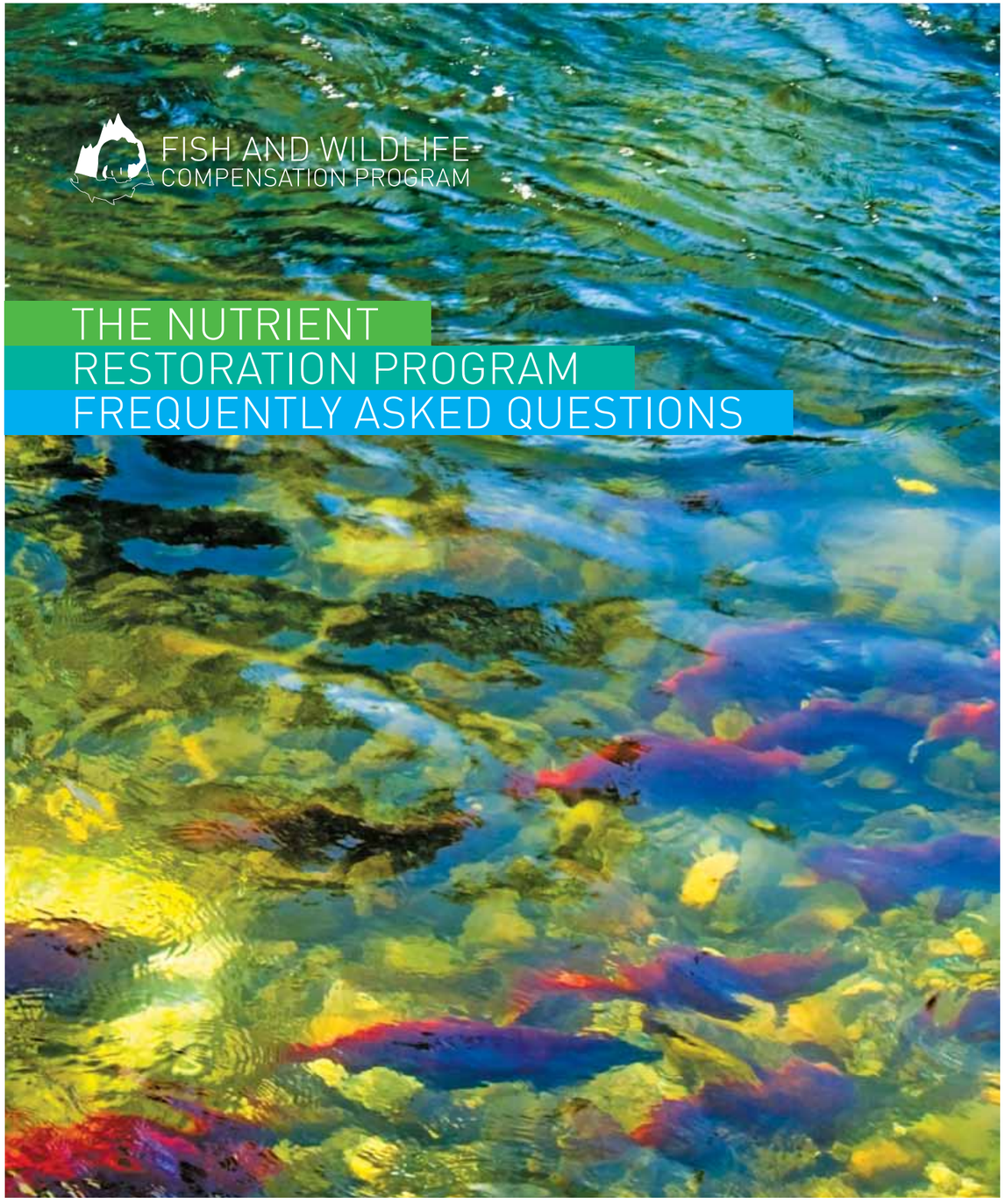

THE NUTRIENT RESTORATION PROGRAM FREQUENTLY ASKED QUESTIONS

The FWCP is a partnership of:

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Canada

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Pêches et Océans Canada

NUTRIENT RESTORATION PROGRAM

The Nutrient Restoration Program (NRP) has been in existence in the Kootenay region since the 1990s and is recognized as one of the most successful large-lake restoration projects in the world. Nutrient additions are made to both Kootenay Lake and upper Arrow Lakes Reservoir.

WHEN DID IT START AND WHY?

This experimental program was started on the north arm of Kootenay Lake in 1992 to rebuild the food web that had been impacted by construction of BC Hydro's Duncan Dam. In 1999 it was expanded to the upper Arrow Lakes Reservoir in response to the impacts from Revelstoke and Mica dams. And in 2004 nutrient additions were started in the south arm of Kootenay Lake as a result of the impacts of the Libby Dam in the United States. The water storage and hydro-electric dams can act to settle out natural nutrients (both phosphorus and nitrogen) that would otherwise flow downstream from the land, into the lakes and through the system. Kootenay Lake and upper Arrow Lakes Reservoir became nutrient depleted and kokanee stocks plummeted. By the 1990s both water bodies became "ultra-oligotrophic," which is Greek for poorly nourished. The Nutrient Restoration Program replaces the nutrients that would otherwise be flowing into these water bodies.

WHO COORDINATES THE PROGRAM?

The provincial government, through the Ministry of Environment and Ministry of Forests, Lands and Natural Resource Operations (FLNRO), is responsible for overall coordination of the Nutrient Restoration Program. Together with these provincial fisheries managers, the Fish and Wildlife Compensation Program (FWCP) coordinates the NRP in the north arm of Kootenay Lake and in upper Arrow Lakes Reservoir. Provincial fisheries managers also deliver a complimentary NRP in the South Arm of Kootenay Lake in partnership with the Kootenai Tribe of Idaho.

WHAT IS PUT INTO THE WATER – IS IT FISH FOOD?

It is not 'fish food' but nutrients consisting of a liquid blend of nitrogen and phosphorus that feed the smaller, microscopic, life forms in the water. The fertilizer is liquid agricultural grade urea-ammonium nitrate (28-0-0) and ammonium polyphosphate (10-34-0).

HOW IMPORTANT IS THE NUTRIENT RESTORATION PROGRAM AND HOW DOES IT WORK?

The nitrogen and phosphorus added by the Nutrient Restoration Program feed microscopic algae, technically known as 'phytoplankton'—meaning plants suspended in water. The nutrients actually target 'nanoplankton' which is a specific size of phytoplankton. Nanoplankton are important to the Kootenay Lake and Arrow Lakes Reservoir ecosystems because they are the best food for zooplankton.

In addition to nitrogen and phosphorus, phytoplankton requires the energy from the sun which they use to convert carbon dioxide into high-energy carbohydrates that are subsequently passed up the food chain. Therefore the entire food web in an aquatic ecosystem is based on phytoplankton. They feed the zooplankton (animals suspended in water), which in turn, feed the kokanee, which feed the larger fish like the Gerrard rainbows and bull trout. These fish help feed the Bald eagles, ospreys, and grizzly bears, to name but a few.

IS IT SUCCESSFUL?

Yes, the Nutrient Restoration Program is viewed as one of the largest successful lake restoration projects in the world. By adding nutrients the food conditions for kokanee have improved considerably: phytoplankton and zooplankton biomass has increased, and kokanee biomass in both Kootenay Lake and Arrow Lakes Reservoir has increased three-fold over the duration of the Nutrient Restoration Program.

The Program has also contributed to positive results for some larger fish species, such as the Gerrard rainbow trout in Kootenay Lake. In 2010 and 2011 the two highest recorded daily peak counts of Gerrard spawners at the main spawning area in Lardeau River were observed since records began in 1960. There is also evidence to suggest that the average sizes of the larger predator fish species have increased in some years and investigations are ongoing to better understand the factors that promote good transfer of nutrients to top level predators. The Nutrient Restoration Program is good for the ecosystem, as well as tourism and recreation in the region.

WHY NOT JUST KEEP ON ADDING NUTRIENTS TO INCREASE FISH NUMBERS?

Implementation of the Nutrient Restoration Program is a balancing act. Adding too many nutrients can lead to over-enriched bodies of water that produce too much algae. As these algae die they use oxygen to decompose, which is unhealthy for fish, plants and other animals.

WHERE ARE THE NUTRIENTS ADDED?

In all cases, the nutrients are dispersed far from shore on the water's surface as phytoplankton live in the epilimnion—the warmer, upper layers of the lake. Nutrient restoration occurs in the north arm of Kootenay Lake just south of Lardeau to just south of Schroeder Creek and in the upper Arrow Lakes Reservoir, from Galena Bay to Halfway River for half of the season and between the Galena Bay ferry terminal and Shelter Bay ferry terminal for the other half of the season. These are approximate locations—actual locations vary depending on weather conditions and amount of fertilizer being dispersed. In 2004 the restoration of nutrients started in the south arm of Kootenay Lake from Wilson Creek to Akokli Creek.

HOW MUCH DO YOU ADD?

The restoration of nutrients mimics the hydrograph (a record showing the changes in flow over time) of the rivers prior to dam construction. Therefore the amounts vary depending on the time of the year.

The range of ammonium polyphosphate (phosphorus) added varies from 36 litres per square kilometre to 108 litres per square kilometre. The range of urea-ammonium nitrate (nitrogen) added varies from 122 litres per square kilometre to 292 litres per square kilometre. Nutrient concentrations of dissolved phosphorus vary from 2 to 4 micrograms per litre. This is a lake restoration project, rather than an enhancement project. Therefore the amount of nutrients added are roughly equal (or less) than would otherwise be flowing into the systems were it not for the dams.

WHEN IS IT DISPERSED?

From late spring to early fall. The amounts are seasonally adjusted. More phosphorus than nitrogen is added in the spring and as the summer progresses, more nitrogen than phosphorus is added. In ecosystems, it is important to maintain a balance of nitrogen to phosphorus in order to maintain the balance of phytoplankton composition in the ecosystem.

HOW IS IT DISPERSED?

Ferries, operated by Western Pacific Marine Ltd., are used to disperse the nutrients into both Kootenay Lake and upper Arrow Lakes Reservoir. The tanks containing the nutrients are driven on to a ferry and hooked-up to a dispersion bar that sprays the nutrients on to the surface of the water. The propeller wash helps to mix the nutrients in.

DOES MONITORING OCCUR?

Yes, monthly. To ensure there is an efficient uptake of the nutrients an adaptive management technique is used. This means water quality monitoring is done monthly from April to November (twice in June) so that the amount of fertilizer added can be adjusted accordingly. There are a total of 16 monitoring sites; eight in Kootenay Lake and eight in upper Arrow Lakes Reservoir. A wide range of samples and measurements are taken at each site.

DOES THE NRP FEED MYSID SHRIMP?

That is not the intention. Mysid shrimp are a non-native species introduced into Kootenay Lake in 1949 as a food source for juvenile