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Proceedings of the regional workshop for the Lake Ontario Ecosystem Research Initiative (ERI)

March 30–31, 2009
Burlington, Ontario

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

The Lake Ontario Ecosystem Research Initiative (LO-ERI) is a multi-disciplinary, collaborative ecosystem-based approach (EBA) that will focus integrated research on the nearshore areas of Lake Ontario's ecosystem. Fisheries and Oceans Canada (DFO) organized and conducted a 2-day workshop in Burlington, Ontario, March 30-31, 2009, to help plan the work of the LO-ERI with DFO's partners and collaborators. Thirty-one participants represented DFO Central & Arctic Science, DFO Fish Habitat Management, DFO's Canadian Hydrographic Service, Environment Canada, the Ontario Ministry of Natural Resources, the Ontario Ministry of the Environment, and members of academia from Canada and the USA. The workshop consisted of 11 presentations on current Lake Ontario nearshore activities and issues by various researchers;

1. presentation on the objectives and initial scope of the LO-ERI, and
2. discussion periods with breakout groups, each followed by a plenary session with all participants together.

The workshop achieved its aims – it developed a list of issues and stressors affecting the nearshore zone of Lake Ontario, identified current research activities occurring in the nearshore zone of Lake Ontario, identified and reviewed potential research activities to help address the goals of the LO-ERI, and developed partnerships for collaborative research and funding.

Compte rendu de l'atelier régional sur l'Initiative de recherche écosystémique (IRE) du lac Ontario

SOMMAIRE

L'Initiative de recherche écosystémique du lac Ontario (IRE-LO) est une démarche fondée sur l'écosystème multidisciplinaire et collaborative qui permettra de concentrer des travaux de recherche intégrés sur les zones littorales de l'écosystème du lac Ontario. Afin de planifier les travaux de l'IRE-LO, Pêches et Océans Canada (le MPO) a organisé et dirigé un atelier de deux jours avec les partenaires et collaborateurs du Ministère à Burlington, en Ontario, les 30 et 31 mars 2009. Trente-et-un participants représentaient : les Sciences de la Région du Centre et de l'Arctique (MPO), la Gestion de l'habitat du poisson (MPO), le Service hydrographique du Canada (SHC), Environnement Canada, le ministère des Richesses naturelles de l'Ontario, le ministère de l'Environnement de l'Ontario, et des membres du milieu universitaire canadiens et américains. L'atelier comportait la présentation, par divers chercheurs, de 11 exposés sur les activités et les enjeux actuels entourant le littoral du lac Ontario;

1. exposé sur les objectifs et sur la portée initiale de l'IRE-LO;
2. périodes de discussion en petits groupes, chacune suivie par une séance en plénière réunissant tous les participants.

L'atelier a atteint ses objectifs : il a permis de dresser la liste des problèmes et des agents de stress relativement à la zone littorale du lac Ontario, de répertorier les activités de recherche actuelles dans la zone littorale du lac Ontario, de cerner et d'examiner les activités de recherche potentielles pouvant aider à atteindre les buts de l'IRE-LO, et de créer des partenariats de recherche et de financement collaboratifs.

INTRODUCTION

The Lake Ontario Ecosystem Research Initiative (LO-ERI) is the only freshwater ERI currently being undertaken by Fisheries and Oceans Canada (DFO). The LO-ERI is a multi-disciplinary, collaborative ecosystem-based approach (EBA) that will focus integrated research on the nearshore areas of Lake Ontario's ecosystem. Although an ecosystem approach to research has been applied by DFO and its partners in the Great Lakes since the 1970s, and much research and monitoring has been conducted on Lake Ontario, most of the work has been done in offshore areas (depths > 20 m), and in select nearshore embayments such as the Bay of Quinte, because of the status of these embayments as Areas of Concern (AOCs) under the *Great Lakes Water Quality Agreement*.

Human development, hydropower generation, international shipping, and climate change collectively impact Lake Ontario at an ecosystem scale. These impacts are greatest in nearshore coastal areas, which represent the interface between the lake and human development. The nearshore environment is affected by water level management (controlled at the Moses-Saunders dam); has been invaded by a number of aquatic invasive species (e.g., zebra mussel, round goby, and *Hemimysis*); and is the shallow warm water area of the lake most likely to be affected by the temperature and precipitation effects of climate change. Nearshore habitats serve as nursery and feeding areas for many Great Lakes fishes – native biodiversity and the productivity of fish populations are linked to these areas. The role of the nearshore in whole lake dynamics is poorly understood, and it is not clear how the cumulative impacts of multiple stressors affect the function of the nearshore in the Lake Ontario ecosystem.

The goal of the LO-ERI is to build on research and partnerships in Lake Ontario to:

1. evaluate how the nearshore coastal area contributes to the function of the whole lake,
2. assess the sensitivity of the nearshore to cumulative impacts from multiple stressors, and
3. predict how the nearshore will respond to projected future conditions.

This will be accomplished through field studies to fill information gaps about the function of the nearshore and its linkages to the offshore, evaluation of ecosystem indicators that assess cumulative impacts of multiple stressors, and modelling to synthesize data and explore scenarios to assess the sensitivity and responses of the nearshore.

The LO-ERI will address portions of the following 'top 10' research priorities listed in the Five-year Research Agenda: Fish Population and Community Productivity, Habitat and Population Linkages, Climate Change/Variability, Ecosystem Assessment and Management Strategies, and Aquatic Invasive Species.

The LO-ERI will help decision-making on issues related to the integrated management of fish habitat, water levels, and human development in the Great Lakes, aquatic invasive species (AIS) control, and climate change adaptation across multiple jurisdictions – interdepartmental (Transport Canada, Environment Canada), provincial (Canada-Ontario) and international (the International Joint Commission (IJC) and the Great Lakes Fishery Commission (GLFC)).

DFO organized and conducted a 2-day workshop in Burlington, Ontario, in March 2009 to help plan the work of the Lake Ontario ERI with DFO's partners and collaborators. See Annex 4 for the workshop's Terms of Reference, Annex 2 for the agenda, and Annex 1 for the participants.

PRESENTATIONS

11 presentations were given at the workshop, including 1 overview on the Lake Ontario Ecosystem Research Initiative (LO-ERI).

The presentations are summarized below in the order in which they were delivered at the workshop. The title of each presentation is taken from the presentation itself, and is not necessarily the same as shown in the agenda (see Annex 2).

PHYSICAL LIMNOLOGY AND MODELLING OF LAKE ONTARIO

Presented by Ram Yerubandi.

Yerubandi covered the general characteristics of coastal processes, compared hydrodynamic models of Lake Ontario, and presented examples of nearshore models of coastal processes in Lake Ontario. He:

- described Lake Ontario's physical characteristics,
- identified the factors (meteorology and hydrology) governing temperature and circulation,
- showed Lake Ontario's summer pattern of circulation (with a large counter-clockwise rotation, and a smaller clockwise rotation at the lake's west end),
- described the structure of the coastal zones of the Great Lakes, including (from the shore outwards) swash and surf zones, and the coastal boundary layer (CBL), made up of a frictional boundary layer (FBL) and an inertial boundary layer (IBL),
- identified the influence of weather, topography, waves, long- and short-term water levels, temperature stratification, and river plumes,
- compared cross-shore and alongshore transport in the nearshore zone,
- described the episodic nature of cross-shore transport (as depending on wind and precipitation),
- described the Spring thermal bar and its impact in keeping nutrients entering the lake in the nearshore zone, and
- identified upwelling and downwelling events as effective mechanisms for cross-shore transport.

Three different lake-wide hydrodynamic models were compared for Lake Ontario:

1. POM (Princeton Ocean Model) coupled with Donelan-GLERL Wave model,
2. ELCOM (Estuary Lake Computer Model), and
3. CANDIE (Canadian version of DIEcast).

Numerical simulations using each of the models produced time-depth distributions of temperature for Lake Ontario. These distributions were compared with the observed distribution of temperature at time and depth. The models simulated large-scale features well, but did not do well with small scale and some convective processes.

Yerubandi examined the coupling of high-resolution nearshore models with lakewide models (1-way nesting). Several examples were discussed, including a model of Hamilton Harbour and its interaction with the lake, the modeling of large and small river plumes, and a hydrodynamic and ecological model simulating conditions for growth of *Cladophora* at Ontario Power Generation's Pickering nuclear generating station.

Discussion

Gaps:

- nearshore circulation patterns
- minimum depth issues: surf not accounted for
- lack of a reliable ice model
- some processes are non-hydrostatic? and are not simulated
- definition of nearshore is arbitrary; surf zone depth is unknown
- better spatial resolution is needed near rivers
- lake residence time is 7.5 years

COOPERATIVE MONITORING OF LAKE ONTARIO IN 2008 – THE COASTAL ZONE COMPONENT

Presented by Todd Howell.

Howell described a multi-agency project of joint Canadian-American monitoring of Lake Ontario to examine the changing ecology and nearshore water quality of the lake as a result of invasive species (dreissenid mussels). This presentation focused on work done in five study areas in the Canadian nearshore in 2008. The study areas included key tributaries discharging into the nearshore blocks. The work included:

- monitoring and modeling tributaries to evaluate delivery of nutrients, particulates, macro-ions, and fecal indicators to the lake shoreline;
- surveying shoreline and nearshore areas to identify the spatial characteristics of water quality across the nearshore;
- remote instrument-based collecting of physical information to determine temporal patterns in nearshore limnology;
- surveying the lakebed to assess the distribution of dreissenid mussels, benthic algae (such as *Cladophora*), and benthic invertebrates; and
- numerical modeling of selected features of the lake environment.

Water quality was measured at a depth of 1.5 m every 5 metres along a survey track within each study block (measurements included conductivity, temperature, turbidity, chlorophyll a, CDOM, hydrocarbon fluorescence, and nitrate (optical)). Laboratory analysis of water samples (nutrients, macro-ions, DOC, suspended solids, and fecal pollution indicators) supplemented the field data. Depth profiles of conductivity, temperature, turbidity, chlorophyll a, hydrocarbon fluorescence, PAR, and beam attenuation were collected periodically along the survey track. Three-dimensional representations of the profile data were used to assess the heterogeneity of each measured parameter in the water column. UV fluorescence (hydrocarbon range) was used as a non-specific tracer of external/internal mixing of organic materials in the water.

Intensive water quality surveys were conducted between April and November in

i) nearshore areas within 5 km of the shoreline,

ii) selected portions of the shoreline at wadeable depths, and

iii) selected sites in tributaries. Measurements included conductivity, ADCP, turbidity, and chlorophyll a fluorescence.

Physical and water quality sensors were deployed in April and retrieved in November. Instruments included acoustic current and wave meters, temperature strings, and sensors for turbidity, chlorophyll a fluorescence, conductivity, and PAR.

Benthic transect surveys were done by divers in all study areas, at depths from 3 to 18 m. Two rounds of surveys were conducted, timed to record *Cladophora* in early and near-maximal growth phases). Quantitative sampling was done for benthic algae, dreissenid mussels, and benthic invertebrates. Visual observations and video records were taken of round goby occurrences.

Intensive monitoring of tributaries (Twenty Mile Creek, the Credit River, Duffins Creek, Carruthers Creek, the Ganaraska River, and Cobourg Creek) in the lake study areas was begun in April 2008, and is ongoing. Event-based sampling used remote collection of integrated samples, weighted by run-off volume over the events.

Significant work remains to compile the primary 2008 data. Preparatory work to support the numerical modeling of *Cladophora* growth is ongoing.

Discussion

Comments:

- impact of rivers on nearshore is not well known
- interaction between land and water occurs in very shallow water: spatially intensive surveys are required (tributary water quality monitoring, collaborative effort on drinking water; must identify links between physics and biology)
- historical changes in *Cladophora* are not well known; there are data from pre P control (S. Painter); *Cladophora* has moved down in the water column (now down to 20 plus metres); Pickering plant data are available, but uncertain of timeline
- comment on P shunt hypothesis: water transparency is at root of shunt; evidence that mussels are capable of causing the change
- nearshore loading is unappreciated

NEARSHORE PLANKTONIC FOOD-WEB OF LAKE ONTARIO: CHANGES AND IMPLICATIONS

Presented by Mohi Munawar.

Munawar briefly described the physical characteristics of Lake Ontario, showed the distribution of the diatom *Melosira binderana* in Lake Ontario during thermal bar conditions in 1970, and presented a conceptual model highlighting the lower trophic levels of Lake Ontario’s food web.

He identified the current issues involving the nearshore planktonic food web of Lake Ontario as eutrophication, harmful algal blooms (HABs), *Cladophora*, contaminants, exotic species, and climate change.

Munawar listed current research being done in the Lake Ontario nearshore zone by DFO (work on embayments – the Bay of Quinte and Hamilton Harbour; lakewide research – LOLA, 2008), the Ontario Ministry of the Environment’s Lake Ontario Coastal Study, and the U.S. Lake

Ontario Nearshore Nutrient Survey (LONNS), and identified gaps in knowledge of the planktonic food web of the Lake Ontario nearshore zone.

He described the taxonomic composition of the microbial loop, the phytoplankton, and the zooplankton of the lower food web at Belleville in the Bay of Quinte in 2006, and showed the temporal variation in the abundance of each component from May to October. He described changes in the proportions of the trophic levels between 2000 and 2006 – from predominantly heterotrophic to predominantly autotrophic.

Munawar presented densities of *Dreissena* mussels in the Bay of Quinte in 1998, 2000, and 2005, and described the changes in nearshore habitat that have taken place as a result of these invasive species. He discussed the role of the viral shunt in catalyzing the movement of nutrients from organisms to the dissolved organic matter (DOM) and particulate organic matter (POM) pools, and postulated that these changes may result in the observed increase in toxin-producing Cyanophyta species found in the Bay of Quinte from 2000 to 2007. He listed some possible impacts of dreissenid mussel grazing on lower food webs.

Munawar summarized as follows: With the formation of the thermal bar, Lake Ontario has a naturally divided nearshore – offshore system. The nearshore is a nursery for intensive lower food web production, and an important resource for higher trophic levels. Historically, eutrophication and contaminants have been the major stressors, but exotic species have emerged as a major stressor, altering nutrient cycling (pseudofaeces, viral lysis), and the structure and function of planktonic food webs. Toxic algal blooms may be increasing as a result of these changes, affecting the aesthetics of the lake waters, and causing toxicity and mortality in fish. New tools for the monitoring and assessment of the lower food web are necessary for capturing the structural and functional changes of the rapidly changing nearshore ecosystem. The whole nearshore qualifies as an “Area of Concern”.

Discussion

- Lake Ontario is the only Great Lake that has a well-defined nearshore-offshore system
- Gaps:
  - nutrient loadings on a lake-wide basis
  - species composition of plankton
  - lower foodweb models
  - role of AIS (e.g., pseudofeces)
  - impact of viruses on food web dynamics
  - impact of algal blooms
  - impact of climate change
- Research needs:
  - exotic species
  - toxic algal blooms
  - new tools for monitoring
  - whole nearshore is an area of concern

- Comments:
    - regarding the whole nearshore as being an area of concern, the Bay of Quinte is more enriched than elsewhere – cannot extrapolate to other coastal areas
    - pseudofeces (*Dreissena*) is an issue; diving is a bottleneck – universities cannot conduct work because of restrictions

EFFECTS OF AQUATIC INVASIVE SPECIES ON THE NEARSHORE BIOTA AND HABITAT OF LAKE ONTARIO

Presented by Kelly Bowen and Christine Brousseau.

Bowen and Brousseau presented concerns regarding aquatic invasive species (AIS) in the nearshore of Lake Ontario, current research and monitoring addressing the effects of AIS, and gaps in knowledge on the impacts of AIS.

Invasive species in the Lake Ontario nearshore area include:

- molluscs (dreissenid mussels; the New Zealand mud snail, and Bithynia snails),
- crustaceans (*Bythotrephes*, the spiny water flea; *Cercopagis*, the fish-hook water flea; *Hemimysis anomala*, the bloody red shrimp; and the amphipods *Echinogammarus ischnus* and *Gammarus tigrinis*),
- invasive plants in coastal wetlands, such as *Myriophyllum spicatum*, and
- fish (pre-1990: Sea Lamprey, Alewife, Rainbow Smelt, Rainbow Trout, Chinook Salmon, Brown Trout, Coho Salmon, Goldfish, Common Carp, White Perch; post-1990: Blueback Herring, Rudd, Round Goby).

Concerns about the impacts of AIS include:

- loss of biodiversity,
    - with invasives out-competing native species, or invasives as predators / parasites on native species (e.g., Sea Lamprey on Lake Trout)
- habitat alteration,
    - re-engineering of the bottom by dreissenids (less habitat heterogeneity, reduced spawning shoals for fish)
    - increased water clarity and more aquatic vegetation in nearshore areas
    - destruction of aquatic vegetation by carp (with resulting increase in turbidity)
- food-web alterations,
    - lowered lake primary productivity caused by dreissenids
    - predation on zooplankton by invasive crustaceans
- genetics interactions,
- parasites and pathogens, and
- increased vulnerability of nearshore areas because of climate change, water level regulation, increased shipping, and other activities.

Research, monitoring, and risk assessment is currently being done by DFO. Research is also being done by the Ontario Ministry of Natural Resources (OMNR), the Royal Botanical Gardens

(RBG), universities, the Canadian Aquatic Invasive Species Network (CAISN), and the Great Lakes Fishery Commission. Bowen and Brousseau briefly described many AIS projects currently underway.

Knowledge gaps include:

- nearshore fish and habitat in exposed coastal habitats,
- impacts of invasive fish on the use of nearshore habitats by native fish,
- effects of AIS on aquatic species at risk in Lake Ontario,
- differences in vulnerability of different nearshore habitats to invasion,
- food web impacts of invasive invertebrates
- which phytoplankton and micro-organisms are native? where are they found in the nearshore?
- parasites, pathogens, genetics?

Discussion

- Why are gobies blamed for egg predation?
- Knowledge of zooplankton AIS in the nearshore from LOLA work
- Review shoreline projects is available from FHM: restoration, compensation; but exotics are not taken into consideration; cobble substrates, rip rap, hemimysids like man-made structures
- Habitat will be used by non-native species; attract carp, gobies; certain substrates should be discouraged?

NEARSHORE FISH COMMUNITY INDEX NETTING ON LAKE ONTARIO

Presented by Jim Hoyle.

Hoyle identified the degradation of some Lake Ontario nearshore areas as an important issue affecting fish communities in the lake – the entire commercial fishery, and much of the recreational fishery, both depend on nearshore fish production.

There is a need to monitor and characterize the fish community consistently and over a broad geographic scale. Between 2001 and 2005, MNR conducted a nearshore fish community index netting (NSCIN) program in the Bay of Quinte, and at several other sites around Lake Ontario (from Kingston to Cobourg). In 2006, the program sampled the Toronto waterfront and the nearshore areas of Hamilton Harbour.

The Lake Ontario NSCIN program follows the standard Ontario provincial protocol for NSCIN projects. It uses trap nets, and targets the littoral zone fish community. The program's strengths include its standard protocol, the availability of historical trap-netting research data in the Bay of Quinte from 1969 to 1988, and a database of NSCIN data from Ontario inland lakes. Its weaknesses include size-selectivity of the fishing gear, and unsuitability for sampling in open, coastal nearshore areas.

From 2007 to 2009 the NSCIN program sampled a variety of sites around Lake Ontario and in the St. Lawrence River, including areas within, and outside of, Areas of Concern. Hoyle compared the abundance and body size of Walleye and Largemouth Bass caught in and out of AOCs – fewer of these fish were caught in AOCs.

Discussion

Minns – East Lake, West Lake are those inside areas in Prince Edward County?

JH – yes

Pratt – how available are your data?

JH – fairly available

Ming – are these data going to be published?

JH – nothing published on this program yet, but could be

Smith – collection of limnological data at the same time?

JH – not during program, but partners are collecting lots of those data.

Howell – you use the terms "degraded", how do you define?

JH – just generally, AOCs are generally described as degraded, but I haven't looked at that with these data yet. Missing some areas, e.g., open coast. Would like to come up with a lake-wide description of the fish community weighted properly.

Johannsson – how close are these to wetlands?

JH – close, but not in

WATER LEVELS, CLIMATE CHANGE, AND NEARSHORE FISHES

Presented by Susan Doka.

Doka described two related projects that studied climate change in the nearshore area: a Lake Ontario-St. Lawrence River study on water regulation and climate change, and a study of the potential impacts of climate change on coastal wetlands.

There are natural fluctuations in water levels from year to year throughout the Great Lakes. Water levels in Lake Ontario are affected by outflows regulated at the Moses-Saunders dam at Cornwall, Ontario/Massena, New York. Since regulation, water levels in Lake Ontario have fluctuated less than the natural fluctuations in the other Great Lakes.

Water levels are important because they influence habitat supply and timing of critical life history events of fish. Doka modeled the habitat suitability and supply for different life stages, species and guilds of fish at different water levels, simulated unregulated water levels for Lake Ontario before and after the construction of the Moses-Saunders dam, and predicted fish guild responses to simulated changes in habitat availability and water supply.

Doka modeled fish populations in different thermal zones along the Lake Ontario nearshore under four different climate change scenarios (warm and wet, not so warm and wet, warm and dry, not so warm and dry). She simulated fish population growth based on habitat supply, temperature, and daily water levels, and predicted and compared fish population differences (density of fish by life stage) across different fish population model areas (and thermal zones). Doka predicted water levels with each climate change scenario, and presented implications for the redistribution of coastal wetlands.

Initial conclusions:

- Change in habitat availability due to changes in water levels can affect some fish guilds and life stages detrimentally. Some responded positively to natural fluctuations, while others responded to regulation of water levels.

- Water regulation affected the simulated production of some fish populations, but the direction and magnitude of change cannot be guessed based on water levels alone.
- Space, scale and time are all important – there are tradeoffs spatially across the system and between populations / guilds.

Next steps involve calibration and estimates of variability at each stage; determining how biotic or intermediate trophic level interactions will influence the outcome; testing sensitivity of output to variation in the main assumptions and important algorithms in the model.

Discussion

Smith – does the model allow for evolution of shoreline profiles and vegetation?

SD – vegetation models respond to water levels

Smith – right away?

SD – time lags, and coastal processes not modelled explicitly

Bakelaar – we didn't change substrate

SD – that is the coastal process part

Marty – near Cornwall, people are concerned about a natural water level regime. Do you think a more natural regime could mitigate for the past water level declines?

SD – more scope for adaptive management under low water level scenarios. Tougher to be adaptive under high water with flooding. It really depends on what the users want to see. Not just boating activities. If projections are correct and we are moving toward lower water levels, there is more potential as long as we can prevent people from moving into those areas.

LAKE ONTARIO NEARSHORE SPECIES-AT-RISK AND SPECIES IN DECLINE

Presented by Tom Pratt.

Fish species at risk or in decline in the Lake Ontario nearshore include those designated by Ontario's Endangered Species Act (ESA), those listed by the federal Species at Risk Act (SARA), those recommended by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and other declining fish.

Pratt summarized the official conservation status (legislated/recommended), habitat, status, threats, and current research for each of the following species: American Eel, Atlantic Salmon, Bigmouth Buffalo, Bridle Shiner, Burbot, Deepwater Ciscoes (Blackfin Cisco, Bloater, Kiyi, and Shortnose Cisco), Deepwater Sculpin, Grass Pickerel, Lake Sturgeon, Lake Trout, River Redhorse, and Spotted Gar.

Species that may become important include tributary species (Black Redhorse, channel darter, Redside Dace, Silver Shiner), and St. Lawrence River species (Cutlip Minnow, Pugnose Shiner).

Threats include exploitation (a historic cause of declines), habitat fragmentation by barriers to migration, habitat degradation (including degradation of water quality and substrate), aquatic invasive species, changes to the food web (i.e., collapse of the historic benthic food web), and climate change.

Current research includes:

- (American Eel) conservation stocking, trap and transport, contaminants, genetics, and barrier inventory,

- (Atlantic Salmon) habitat data in spawning streams, distribution from angler returns, life-stage survival and reproductive success,
- (Bigmouth Buffalo) Great Lakes genetics,
- (Bridle Shiner) assessment of current status,
- (deepwater ciscoes) genetics and hatchery rearing for reintroduction, assessment of current status 2009,
- (Deepwater Sculpin) genetic structure,
- (Grass Pickerel) impact of drain maintenance,
- (Lake Sturgeon) spawning habitat creation assessment, basin-wide genetics, hatchery enhancement,
- (Lake Trout) rehabilitation stocking program, chemical assessment of otoliths for origin, lakewide population assessment, thiaminase, habitat assessment in lower Niagara,
- (River Redhorse) life history, genetics, and
- (Spotted Gar) life history, critical habitat and genetic structure of Canadian populations.

Discussion

Ming – deepwater ciscoes & sculpin – do we know how they used the nearshore and what would happen if re-introduced?

TP – they certainly move shallower. Recruitment indexes are the same as for shallower species, so the nearshore habitat is probably important.

Randall – long list of species. How does it compare to other GLs?

TP – Not as high as Erie, lower than upper lakes

NEARSHORE AND OFFSHORE LINKAGES

Presented by Tom Stewart.

Stewart examined linkages between the nearshore and offshore zones in three ways:

1. What are the consequences of spatial variation in temperature to zooplankton production?
2. Does the production potential of Chinook Salmon depend on the nearshore?
3. Are the nearshore and offshore now less connected energetically?

To examine the effects of spatial variation in temperature on zooplankton production, Stewart combined a linear empirical model that predicts Lake Ontario temperature at depth (from monthly mid-lake temperature, bathymetric depth, and region of the lake), with equations that predict zooplankton density from an index of heat content, to examine the potential magnitude of spatial variation on average crustacean density from April to October. The combined model predicted more biomass and production in the nearshore (shallower), and less biomass and production in the offshore (deeper). Stewart and his collaborators sampled biomass at multiple sites around the lake, calculated daily biomass at two stations (one nearshore, the other offshore), estimated production/biomass (P/B) ratios for the whole lake, estimated daily whole-lake epilimnetic production from either of the two stations, and summed that daily production across the year, for the years 1987-1991.

Stewart found no difference in cumulative daily biomass between the stations, and no difference in whole-lake annual epilimnetic production by using the daily biomass from either station. He concluded that even though we have a persistent regional and bathymetric-related thermal structure in Lake Ontario that predicts higher water-column production in nearshore areas, nearshore epilimnetic zooplankton production is not significantly higher (statistically or biologically) than offshore production, despite earlier seasonal and sustained warmer temperatures. Nearshore epilimnetic zooplankton production may be important seasonally as an early source of food for first feeding larval fish and juveniles. The major ecological links between the nearshore and offshore involve nearshore nursery and spawning habitat for offshore fish.

Stewart asked whether the production potential of Chinook Salmon depends on the nearshore.

Stewart asked whether the nearshore and offshore now less connected energetically than in the past. He examined alewife diet and bioenergetics before and after the dreissenid mussel invasion. In 1988, alewife ate more than their maintenance requirements at depths of more than 35 metres; in 2004 and 2005, they ate more than their maintenance requirements at depths of more than 70 m. Alewife are now getting less of their energy from the nearshore, and are more reliant on offshore energy sources, especially *Mysis*.

Discussion

Millard – Stations 41 & 81 probably are indicative of whole areas, but didn't do the extrapolations. But were they indicative of the bioindex results?

Johannsson – probably for this time period, but for the earlier time station 81 would have been more productive. Tom's work goes deeper.

Millard – Station 81 gets more light to drive primary production earlier in the season. Leads to higher seasonal production.

Munawar – Dynamics are very different, station 41 well mixed.

TS – these were the only stations with intensive enough data to do this. But the sampling elsewhere shows it is difficult to detect differences.

Johannsson – Station 81 warms up sooner, but also cools sooner. Would allow fish to use 81 earlier, then switch to using 41, thereby extending the season.

Bowen – USGS, while seeing lower alewife numbers, are seeing increased condition

TS – yes, using their data. Originally wondered if it was a *Hemimysis* signal, but went back to samples and found no *Hemimysis* in shallow stomach contents. Condition change more likely a shift in diet to *Mysis*.

Bowen – what about *Bythotrephes?*

TS – more a Fall prey, not sufficient to generate change in condition.

LAKE ONTARIO NEARSHORE NUTRIENT STUDY - LONNS

Presented by Joe Makarewicz.

Makarewicz presented a project to investigate nutrients in the U.S. nearshore of Lake Ontario. The study covered three target sampling periods (May-June, July-August, and September-October), and three different sampling zones (agricultural – Oak Orchard, urban – Rochester, and forested – Mexico Bay).

Sampling included sensors towed at 2 m depth along transect tracks for temperature, light (PAR), chlorophyll a, phycocyanin (DOM type); fixed station sampling points at 2 m depth for nitrate, TKN, TP, SRP, silica, TSS/turbidity, and E. coli; and sampled vertical profiles for temperature, chlorophyll a, turbidity, and water chemistry (as above) at 3 depths (2 m, mid-depth, and 1 m above the bottom).

Biological sampling in May and July included diving to assess *Cladophora* biomass and *Dreissena* biomass at 2, 5, 10 and 20 metres. The number of gobies observed per unit time was recorded on video.

Makarewicz showed the biomass of *Dreissena bugensis* mussels in June and August at all 3 sampling zones at depths of 2, 5, and 10 m.

He presented the results geographically, showing the transects, sampling points, and results for:

- Oak Orchard in May (TP, silica, total coliform, and temperature) and August (nitrate, TP);
- Rochester in June (SRP, temperature) and August (total coliform); and
- Mexico Bay in August (SRP, nitrate, silica, total coliform, and temperature).

Makarewicz concluded that there is significant variability in the nearshore, with the influence of streams, upwellings, currents, thermal bars, and sewage treatment plants (STPs). Nearshore nutrient concentrations were greatest at the agricultural site.

Work on *Cladophora*, gobies and pigments is still underway.

Discussion

- on the south shore of Lake Ontario, judging from 5 by 20 km polygons, variability in the nearshore is high
- influence of streams on nearshore nutrients: Is there a biological response to plumes (Si)?
- Reflected in *Cladophora* beds
- Offshore-onshore currents affect thermal nearshore
- Stream plumes of P, Si, Nitrate
- Influence of STP; very dynamic – upwellings, currents, thermal bars, STPs; nutrients were greatest at agricultural sites
- polygons are a means of generalizing to the reach scale

NEARSHORE FISH HABITAT ISSUES: AN OGLA PERSPECTIVE

Presented by Debbie Ming.

Ming described DFO's Ontario Great Lakes Area (OGLA) structure and its program activities. The OGLA is comprised of three districts (Northern Ontario, Eastern Ontario, and Southern Ontario), with offices in Kenora, Thunder Bay, Sault Ste. Marie, Sudbury, Parry Sound, Prescott, Peterborough, Burlington, and Sarnia. The OGLA Area office is located in Burlington, Ontario.

DFO's responsibility includes the habitat provisions of the *Fisheries Act* (referral reviews, advice and approvals, and the implementation of policy for the management of fish habitat), the *Canadian Environmental Assessment Act* (CEAA), and the *Species at Risk Act* (SARA).

Habitat provisions of the *Fisheries Act* include:

- Section 20 – safe fish passage

- Section 22 – sufficient water flow
- Section 30 – fish guards and screens
- Section 32 – destruction of fish
- Section 35 – destruction of fish habitat (harmful alteration, disruption, or destruction of fish habitat (HADD)

The referral review process for projects to do work in or around water involves the submission of a project proposal to DFO, a conservation authority (CA), the Parks Canada Agency (PCA), or MNR for permits or authorization. Proposals are reviewed by CAs, or are referred to DFO. After the review, DFO issues a Letter of Advice (LOA), or if HADD is acceptable or if there is acceptable compensation for HADD, an Authorization to do the work. Review under CEAA is done before the authorization is issued. DFO uses the web-based Habitat Alteration Assessment Tool to help achieve 'no net loss' of fish habitat for infilling projects in the Great Lakes.

Typical nearshore project proposals include shoreline stabilization projects; docks, boathouses, and boat launches; infilling (trails, housing development); marinas, piers; groynes, breakwaters; dredging; intakes/outfalls; and wind farms (will the majority of these be offshore?). Current projects of interest are:

- a new build at the Darlington Nuclear Plant, which includes large-scale infill, intake/outfall structures, and potential inpingement/entrainment;
- refurbishment of the Pickering Nuclear Plant;
- dredging contaminated sediment (Port Hope);
- aggregate extraction at the Niagara Bar (at the mouth of the Niagara River); and
- aquatic restoration of the Toronto waterfront.

Direct issues/stressors on the Lake Ontario nearshore include direct loss of fish habitat, altered coastal processes, loss of riparian vegetation, loss of littoral zone/coastal wetlands, increased soil erosion and sedimentation, decreased sediment transport, loss of cover (i.e., vegetation, woody debris), and cumulative effects. Indirect impacts also result from the quality/quantity of drainage into Lake Ontario, water crossings/dams/barriers, channel re-alignments, stormwater management facilities, water withdrawals, chronic erosion, and habitat fragmentation.

Knowledge gaps include:

- ecological importance of nearshore habitat (i.e., habitat suitability models, SAR concerns)
- effectiveness of mitigation/compensation (preferred shoreline treatment designs for stabilization and restoration)
- climate change scenarios to predict areas for protection from dredging
- assessment of impingement/entrainment effects to fish communities
- monitoring (methods, design & implementation)
- cumulative effects assessment, specific to shoreline development
- where fish habitat is (fish habitat is considered any area below the High Water Mark (HWM) – 80th percentile elevation; Lake Ontario is 75.32 m above sea level – is this a correct number?)

- effectiveness of natural channel designs, and
- fish passage for dams (i.e., priority barriers to target for mitigation)

Discussion

- Why is entrainment still an issue, given the research done earlier by Kelso and Minns?
- Relative significance (frequency?) of referrals: watershed versus shoreline modification.

THE LAKE ONTARIO ECOSYSTEM RESEARCH INITIATIVE (LO-ERI)

Presented by Bob Randall.

Randall described the Lake Ontario Ecosystem Research Initiative (LO-ERI) in the context of the other ERIs, DFO's ecosystem-based approach, and the themes of the ERIs (see the "Introduction" and "Annex 4: Terms of Reference" for details). Rationale for the LO-ERI includes the existence of long-term data, in-house and partner knowledge and expertise, the presence of multiple stressors (water level management, AIS, human development, navigation, climate change, impacts from upstream), the lake is an international waterbody with multiple jurisdictions, there is increasing attention on the nearshore and biodiversity, and the Great Lakes export to the St. Lawrence River.

i) The goal of the Lake Ontario ERI is to build on research and partnerships in Lake Ontario to;

ii) evaluate how the nearshore areas contribute to the function of the whole lake,

iii) assess the sensitivity of the nearshore to cumulative impacts from multiple stressors, and

iv) predict how the nearshore will respond to projected future conditions.

DFO is responsible for ensuring no-net-loss of habitat productive capacity, for ensuring the survival and recovery of species at risk, and for supporting sustainable fisheries and protecting biodiversity in the lake.

Randall gave a brief history of research conducted in the coastal areas of Lake Ontario. This involved the Great Lakes Action Plan and Project Quinte, empirical models and methodologies for determining productive capacity; modeling of fish habitat suitability, no net loss of fish habitat, water level management, and climate change; and work on lower trophic levels.

Randall described the LO-ERI work plan for 2008-09, and outlined the work plan for 2009-2010, highlighting the planned alignment of LO-ERI projects with other DFO programs and Centres of Excellence (CoEs), including SARA, AIS, Centre of Expertise for Aquatic Risk Assessment (CEARA), Centre for Aquatic Habitat Research (CAHR), and possibly Centre of Expertise on Hydropower Impacts on Fish and Fish Habitat (CHIF).

In addition to the annual LO-ERI workshop, proposed LO-ERI activities will include:

- investigating the effects of benthification on nearshore foodweb linkages,
- finding and studying lake herring spawning and rearing habitat,
- investigating deepwater fish communities and sportfish habitat use in embayments,
- determining daily pattern of use of coastal habitats by fishes,
- analyzing multi-beam side-scan acoustic data to classify substrate in the nearshore,

- examining the impacts of toxic algal blooms and viruses in the Bay of Quinte,
- identifying predictors of lower foodweb productivity in nearshore habitats,
- developing a strategy for monitoring AIS in nearshore foodwebs,
- determining how fish biomass changes with depth in the nearshore,
- developing and categorizing methods for measuring cumulative effects of multiple stressors on fish and habitat,
- design a logical data model to integrate ecosystem research information, and
- predicting how different habitats contribute to nearshore production, how nearshore fish communities will respond to multiple stressors and to future conditions.

Discussion

ERIs in DFO:

- Michelle Wheatley discussed the 5-yr Science Plan and 5-yr Research Agenda
- Integrated management and EBA is a focus of DFO
- C&A already adopted an EBA, e.g., ELA research program
- Challenges with EBA prompted the development of the ERIs: identify knowledge gaps, interpret effects of activities (aquaculture, habitat, etc.) on resources; EBA is leading to increased credibility of science
- Link to other programs in DFO: CoEs, climate change and others
- LO is a pilot; regional research priorities to fill knowledge gaps
- Listed 3 objectives of ERI

ISSUES/STRESSORS AFFECTING THE NEARSHORE ZONE OF LAKE ONTARIO

[large scale]

- cumulative effects
- climate change
- altered coastal processes
- human development
- navigation
- permissive regulatory environment (e.g., OGLA)

[amount and flow of water]

- water levels
- water level management
- water withdrawals
- stormwater management facilities
- quantity [and quality] of drainage into the lake

- impacts from upstream
- stream plumes into the nearshore

[related to erosion and sediments]

- chronic erosion
- erosion, sediment accumulation/movement
- increased soil erosion and sedimentation
- decreased sediment transport
- channel re-alignments

[water quality]

- quality [and quantity] of drainage into the lake
- eutrophication
- contaminants, including nutrients, the nearshore shunt, the movement of particulate materials, and retention
- long-term trends in SRP (nutrients) in the nearshore; partitioning between particulates and solids

[habitat]

- habitat loss
- loss of 'critical' habitat
- loss of littoral zone/coastal wetlands
- loss of cover (i.e., vegetation, woody debris)
- habitat degradation (including water quality, substrate)
- habitat fragmentation (including barriers to migration of migratory species)
- water crossings/dams/barriers

[communities]

- aquatic invasive species
- loss of riparian vegetation
- changes in the food web (e.g., collapse of the historic benthic food web)
- harmful algal blooms
- *Cladophora*
- exploitation (of fish)
- pseudofeces (*Dreissena*)

CURRENT RESEARCH ACTIVITIES

[Yerubandi – physical limnology]

- impact of climate change on [physical processes in] Lake Ontario

[Howell – cooperative monitoring]

- data compilation is ongoing
- adequacy of the field effort and study design needs to be assessed
- opportunities for numerical and other modeling to aid in the interpretation of water quality and benthic biological features need to be developed
- sharing and integration of study findings with US collaborators

[Munawar – lower food web]

- work on embayments (Bay of Quinte, Hamilton Harbour) – DFO
- lakewide research (LOLA, 2008) – DFO
- Lake Ontario Coastal Study – MOE
- Lake Ontario Nearshore Nutrient Survey (LONNS) – USA

[Bowen and Brousseau – aquatic invasive species]

Current research includes:

- examining the effects of the round goby at nearshore lake trout spawning shoals,
- long-term investigations of nearshore fish assemblages and lower food web groups in the Hamilton Harbour and Bay of Quinte Areas of Concern, before and after the introduction of AIS,
- developing protocols and strategies for the early detection of AIS,
- doing risk assessments for *Hemimysis* and the round goby,
- several ongoing studies at McMaster University on round goby behaviour, ecology, diet, and toxin uptake, and on the effects of an aquatic invasive plant in a Lake Ontario wetland.

Many other projects are underway, including:

- recent surveys of Lake Ontario coastal wetlands for a wide range of biota (by the Central Lake Ontario Conservation Authority and Environment Canada),
- *Hemimysis* research with Cornell University, and June Rainbow Smelt assessment that includes 8m and 15m stations (by the USGS Great Lakes Science Center),
- a gillnetting assessment in southeast Lake Ontario, by the New York State Department of Environmental Conservation,
- a DNR-Cornell University study on the importance of Lake Ontario embayments and nearshore areas as nurseries for larval fishes (especially alewife),
- an investigation of the impacts of the Sea Lamprey Control Program's chemicals on the nearshore (by the GLFC),
- work on invasion biology (detection and spread, vectors, propagule pressure, and prevention) not specific to Lake Ontario, by the Canadian Aquatic Invasive Species Network (CAISN), and
- an Environment Canada-MOE joint effort to assess the effects of dreissenids and *Cladophora* on nearshore water quality.

[Hoyle – nearshore community index netting]

- will complete the NSCIN netting in the remaining nearshore areas as planned.

[Doka – water levels and climate change]

- Relative comparisons are possible but need calibration and estimates of uncertainties at each stage for predictive capability.
- Need to determine how biotic or intermediate trophic level interactions will influence outcome.
- Use distribution of climate forecasts as estimates of uncertainty in input data to gauge response distributions.
- Select main assumptions & important algorithms in fish models to test sensitivity of output.

[Pratt – species at risk]

Current research on SAR includes:

- (American Eel) conservation stocking, trap and transport, contaminants, genetics, and barrier inventory,
- (Atlantic Salmon) habitat data in spawning streams, distribution from angler returns, life-stage survival and reproductive success,
- (Bigmouth Buffalo) Great Lakes genetics,
- (Bridle Shiner) assessment of current status,
- (deepwater ciscoes) genetics and hatchery rearing for reintroduction, assessment of current status 2009,
- (Deepwater Sculpin) genetic structure,
- (Grass Pickerel) impact of drain maintenance,
- (Lake Sturgeon) spawning habitat creation assessment, basin-wide genetics, hatchery enhancement,
- (Lake Trout) rehabilitation stocking program, chemical assessment of otoliths for origin, lakewide population assessment, thiaminase, habitat assessment in lower Niagara,
- (River Redhorse) life history, genetics, and
- (Spotted Gar) life history, critical habitat and genetic structure of Canadian populations.

[Makarewicz – LONNS]

- work on *Cladophora*, gobies and pigments is still underway.

[Breakout Group 'S']

- work from Ed Mills (Cornell)
- source water protection (Ontario act); includes hydrodynamic modeling; funded by Ontario with in-kind support from EC, CA's, MOE
    - o water quality, pathogens,
    - o tools being used and people involved, lots of opportunity for x-exchange

- watershed-nearshore
- workshop took place at Black Creek, Scott/Ram attended

- fish on US side:
  - mostly offshore
  - warm-water fish assessment, gill net program in E LOnt NYDEC – Janna Lantry (similar to E LOnt on Canadian side)
- Universities:
  - Waterloo: hydrodynamic/water quality/*Cladophora* models: re-suspension of materials in zebra mussel beds
  - Ralph Smith/Leon Bergman (Queens): Hamilton Harbour & BofQ (3 year project)
    - Simulate temperature, O_2 and climate change effects
    - Physical model
- Municipal Activities and/or Conservation Authorities
- (Data Management)
- data from coastal processes group (IJC water levels group)

Discussion

- Specifically, what are the questions?
- Modelling to whole lake scale is risky.
- To classify habitats, we must understand the function of habitats, climate change, AIS , and connectivity issues – nearshore/offshore.
- We need a conceptual model of processes, and an inventory of data to identify data gaps.
- Must have a management vision for the nearshore.
- Knowledge gaps and data gaps are not the same thing.
- Strong collaboration with the U.S. (e.g., on physical modelling) is needed.
- 'Benthification' should be included; do not assume knowledge of the benthic food web.
- What frequency of sampling is needed for lower trophic levels? What spatial resolution?
- Identify gaps first, knowledge gaps where DFO does not have expertise.
- Initial classification of habitats is needed, using GIS knowledge and processes.
- Flow chart: data management should apply to all components of ERI.
- ERI O&M cannot be used to hire people.
- Need to develop a conceptual model, develop hypotheses, historical reference point.
- Existing (water level) model is static, must be developed; need to classify habitat with a limited number of classes, and identify drivers as well.

- What management tools will be produced? Geographic reference area? Core is productive capacity, and impacts of multiple use. What do the public want?
- Overall nutrient levels are the key question in Lake Ontario.

KNOWLEDGE GAPS

[general]

- how can we extrapolate to whole lake?
- functional processes and their scale
- agencies need to plan together more
  - synthesis of current knowledge
  - contribution of 'enablers'
  - different plans should be connected
- how to reconnect people with their impacts on the lakes
- need to find new models to estimate productivity

[limnological models]

- minimum depth issues in models are not resolved (surf not accounted for)
- do these models handle coastal processes properly?
- better spatial resolution is needed near rivers
- models do not account for surf and swash zones
- lack of knowledge about exposed coastlines
- definition of nearshore is arbitrary; surf zone depth is unknown
- nearshore circulation patterns
- one-way coupling vs two-way interaction
- winter processes are not understood (lack of a reliable ice model)
- winter/ice: spatial & temporal dynamics of physical environment connected to biological assemblages
- some processes are non-hydrostatic and are not simulated in models
- lake residence time is 6 yrs or 7.5? 7.5 yrs is commonly accepted?
- impact of rivers on nearshore is not well known
- application of Atkinson (U Buffalo) particle movement model to whole nearshore, influence of hydrological/meterological events

[lower food web]

- nutrient loadings on a lakewide basis, including municipal and agricultural sources, and application of the Vollenweider model
- species composition of phytoplankton, especially toxin-producing algae
- development of lower food web models of ecosystem health

- role of exotics/invasives in recycling of nutrients (pseudofaeces, etc)
- impact of viruses on energy flow and nutrient cycling (food web dynamics)
- impact of algal blooms on food web dynamics and fish habitat
- impact of climate change on the thermal bar and lake dynamics
- new tools for the monitoring and assessment of the lower food web are necessary for capturing the structural and functional changes of the rapidly changing nearshore ecosystem…

[AIS]

- changes in communities – what are the new community baselines?
- we do not fully understand the impact of zebra mussels yet (e.g., pseudofeces, benthic production, changes in nutrient dynamics)
- food web impacts of invasive invertebrates; benthification
- impacts of invasive species on the use of nearshore (and other) habitats by native fish
- effects of AIS on aquatic species at risk in Lake Ontario
- differences in vulnerability of different nearshore habitats to invasion
- which phytoplankton and micro-organisms are native? where are they found in the nearshore?
- parasites, pathogens, genetics?

[nearshore ecosystems]

- not enough is known about "degraded" and natural ecosystems
- role of changed nearshore in retention of nutrients & contaminants
- role of episodic events, driving nearshore events & productivity
- link of watershed to lake – mechanism to measure/understand impacts
- cumulative effects of physical & chemical changes in the watershed
- cumulative impacts of tributaries
- don't know how to sample open coastal nearshore fish communities
- body burdens of contaminants in nearshore fish
- compare the selectivity of NSCIN with other gear types and uses
- what determines the spatial structure of coastal areas?
- information about exposed coastal areas and their fish communities
- gaps of sampling along shoreline – exposed shoreline, high energy shoreline important areas from a development standpoint
- historical changes in *Cladophora* abundance are not well known
- *Cladophora* and its effects on nutrients, habitat
- nearshore [nutrient] loading is unappreciated

- understanding long-term trends SRP (nutrients) in nearshore; partitioning between particulates and solids
- influence of streams on nearshore nutrients: is there a biological response to plumes (Si)?
- currents (small scale, 3 dimensional)
- partitioning of nearshore primary productivity between primary producers: periphyton, epiphytes
- contribution to total lake production by the nearshore (level of primary productivity); quantify change (e.g., Chinook Salmon)
- technology exists to quantify *Cladophora* and zebra mussel beds (underwater photography, acoustics)
- nutrient recycling in nearshore (lake bed) over hard substrate (related to key issue)
- models exist: P load & Chl-a/P concentrations to manage P; need to be able to model retention/re-supply of P from nearshore to water column/whole lake; need framework to do this and then add quantitative values to put into whole lake #'s for *Cladophora*, etc.
    - need better models to link nearshore nutrients & offshore;
    - need parameters for the hypothesis
    - research in the lake bed (especially zebra mussels)
- quantifying non-point source P loading
- inventory and classification of embayments
- understanding environment management activities in the nearshore (US vs Canada approaches (involvement of state vs province))
- management vision for nearshore – what are the management levels?

[fish and fish habitat]

- ecological importance of nearshore habitat (i.e., habitat suitability models, SAR concerns)
- nearshore fish communities (non-wadeable, non-wetland, not directly connected to watershed), all life stages
- effectiveness of mitigation/compensation (preferred shoreline treatment designs for stabilization and restoration)
- dredging – climate change scenarios to predict areas for protection
- assessment of impingement/entrainment effects to fish communities
- monitoring (methods, design & implementation)
- cumulative effects assessment – especially with relation to shoreline development
- what is the correct high water mark for Lake Ontario?
- effects of climate change on fish habitat
- winter/seasonal habitat use

- effectiveness of natural channel designs
- fish passage for dams (i.e., priority barriers to target for mitigation)
- design of water crossings
- impacts of invasive species on the use of nearshore (and other) habitats by native fish
- information from exposed coastal areas
- understanding W-E gradient of productivity (especially fish) (e.g., as indicated by commercial fisheries) – is this understood or a knowledge gap?
- fish-habitat associations; links between nutrient regime, lower food web, and fish (changed nutrient regime)
- water column food web
- habitat needs a special focus
    - need to understand physical and biological function
    - identify key restoration areas/habitats
    - social engagement is critical
    - habitat classification
        - physical characteristics
        - 3-dimensional movements/flows
    - use existing models to predict functional habitat (physical + physiochemical + biological)
    - community changes can occur regardless of habitat

[climate change]

- physical and biological impacts
- need to recognize that the field sampling season needs to be extended (but in reality has been getting shorter)
- what habitats will become critical with climate change?
- impacts especially on upwellings (upwelling events are known especially for whole lake, local scale can be interpreted)
- water levels, wind speeds, thermal bar, tributary inputs (all the drivers)

[connectivity]

- connectivity
    - along shorelines
    - watersheds ➔ nearshore ➔ offshore
        - integrated model, including existing data
    - barriers/fragmentation
    - impacts of development along the lake's edge

POTENTIAL RESEARCH ACTIVITIES THAT ADDRESS THE GOALS OF THE ERI

List of Proposed LO-ERI Projects

1. Effects of benthification on nearshore foodweb linkages
2. Lake herring spawning and rearing habitat
3. Deepwater fish communities and sportfish habitat usage in embayments
4. Diel use of coastal habitats by fishes
5. Analysis of acoustic data for substrate classification
6. Toxic algal blooms and viruses
7. Lower foodweb productivity of nearshore Lake Ontario
8. Role of AIS in nearshore foodwebs
9. Depth-biomass response curve
10. Methods for measuring cumulative effects (multiple stressors)
11. Data management for the LO-ERI
12. Functional contribution of nearshore habitats to production in Lake Ontario

Group Discussion

1) Effects of benthification on nearshore foodweb linkages (ecosystem processes)

- What is benthification? – nearshore shunt, Cladophora
- Can we coordinate work with Joe M. and Todd H. – tributary outlets, etc., on the Canadian side?
- Dollar value? Potential for continuation of funding beyond 2 years of funding.
- What model organisms would be used to test this hypothesis? Zooplankton, primary producers, invertebrates and fishes, take both benthic and pelagic plankton samples – signatures may be different in the Cladophora beds that are outside.
- Any concern about identifying the current benthic foodweb before attempting to examine the overall foodweb? e.g., relative abundance of organisms, roles, and interactions – changing environment, metaphyton (associated with Cladophora); what are the core components of the foodweb? – stable isotopes could help to identify relationships between major groups.

2) Lake herring spawning and rearing habitat

- No comment

3) Deepwater fish communities and sportfish habitat usage in embayments

- No comment

4 & 9) Diel use of coastal habitats by fishes & Depth-biomass response curve

- Link to depth biomass response curves in the nearshore – acoustics – can biomass be extrapolated out to deeper depths? How does it change as you move from 1.5 to 20 m? What area would you sample?

5) Analysis of acoustic data for substrate classification

- No comment

6) Toxic algal blooms and viruses

- No comment

7) Lower foodweb productivity of nearshore Lake Ontario

- What type of predictors? – haven't decided (fetch, temperature, nutrients, etc.)
- Other site selection (greater fetch, e.g., Presqu'ile or somewhere on the other side of the lake)?
- Follow same lower trophic level that is currently being conducted in Hamilton Harbour – biweekly?
- Site selection – not wide enough, only one site per habitat type
- Too labour intensive – not enough staff to do the work
- What type of knowledge will you gain, may be disappointed in resolution/spatial differences?
- Could you collect biomass samples over a two week period that would allow comparisons? idea of productivity but simpler, need to rethink project (Ora and Scott)
- Look at the P levels, algal and conductivity – look at general limnological changes – partner with power generating stations; may be able to get zooplankton samples

8) Role of AIS in nearshore foodwebs

- No comment

10) Methods for measuring cumulative effects (multiple stressors)

- No comment

11) Data management for the LO-ERI

- No comment

12) Functional contribution of nearshore habitats to production in Lake Ontario

- Build on data that are available
- Do you have models in mind? Discussed a few approaches but haven't decided how to proceed.

*****) Initial classification project has not been identified**

- Valid classification system – will be a heavy GIS project
- How do you divide up the lake and plan to choose your study locations?
- Overall higher classification for habitat, hypothesis for which classification scheme should be, not just physical characterization, but use drivers like watershed size, use, output, land-use, hydrodynamics, classification that could be used for any trophic level (is an area suitable for *Cladophora* growth, goby establishment, etc.?); assign level of productivity to different classes of habitat

- Would this type of a tool be useful to OGLA? We would like a tool in the form of a shoreline management plan – common vision for shoreline among uses? Ecosystem-based management tools for FHM – social impacts, visions for lake, ultimate management objectives; for example, goals for restoration (% of wetlands), recreational fishing, interactive process; understand what drives productivity and relate to classification scheme, then apply questions and answer with knowledge base (Ora)
- Multi-use issues – ask whether public want clean beaches, good fishing

Gaps:

- Conceptual model that integrates existing data and identify gaps
- Start with physical habitat, land use, tributaries, etc., hydrodynamics (geographical and physiochemical), and then move on to biological layers
- Need geographic base; a lot of work has already been done through water level study (Doka) – can we build on that?
- The research questions are not clear, what are the hypotheses? Need a holistic view of how to deal with drivers – nearshore hydrodynamics (RAM?), *Cladophora* (MOE, U. of Waterloo); what about the other components?
- Proposed works (5 components – Ken Minns), geographic infrastructure (substrate, bathymetry, hydrodynamics, scale of watershed, land-use conditions – spatial mapping work); links between fish and habitat features – move forward beyond fetch with more info may relate to agriculture, etc.; same thing applies to lower trophic levels; correlative structure – predict by habitat – *Cladophora*, TP, benthic p and fish – surrogate for diet studies, etc.
- Scoping on functional relationships but we don't have all the details, what are the integrators? scoping workshop, simplify proposed works, scope out additional gaps in future years
- Look at habitat from multi-dimensional perspective/functional model of habitat – new way of grouping factors – water quality, anthropogenic issues, physics, natural features, etc., then map to biological features like fish, AIS, etc. – approach has merit because other groups will buy into it, and everyone has a baseline to work with

Discussion from the Final Plenary Session

- What are the goals of the LO-ERI? Reduce scope, develop conceptual model; decide on specific knowledge gaps to address
- Focus on geographic mapping of coastal areas; relate to drivers like tributaries or upwelling
- Already have a database describing nearshore habitat (water levels study) to build on
- Description of ERI is too piecemeal as it stands – integration is not apparent
- Existing or planned activities are more correlative in structure rather than designed to establish a functional connection
- Conceptual framework is part of ERI model proposal
- For habitat, develop new strategy for grouping habitat, e.g., factors that affect P

PARTNERS AND COLLABORATION

Government Departments

- Canada
  - Environment Canada
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    - *Alice Dove*
    - *Marie-Claire Doyle*
    - *Bruce Gray*
    - *Véronique Hiriart-Baer*
    - *Vi Richardson*
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  - Fisheries and Oceans Canada
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      - *Scott Millard*
      - *Mohi Munawar*
      - *Tom Pratt*
      - *Bob Randall*
      - *Michelle Wheatley*
    - Fish Habitat Management
      - *Shelly Dunn*
      - *Debbie Ming*
- Province of Ontario
  - Conservation Authorities (Ontario)
    - Central Lake Ontario Conservation Authority (CLOCA)
      - *n/a*
    - Credit Valley Conservation (CVC)
      - *n/a*
    - Conservation Halton (aka Halton Region Conservation Authority, HRCA)
      - *n/a*
    - Ganaraska Region Conservation Authority (GRCA)
      - *n/a*
    - Niagara Peninsula Conservation Authority (NPCA)
      - *n/a*
    - Toronto and Region Conservation Authority (TRCA)
      - *Gary Bowen*
  - Ministry of Natural Resources
    - *Jim Hoyle*

        - *Tim Johnson*
        - *Tom Stewart*
    - Ministry of the Environment
        - *Paul Helm*
        - *Greg Hobson*
        - *Todd Howell*
        - *Wendy Page*
        - *John Thibeau*
        - *Brian Thorburn*
    - Ontario Power Generation (OPG)
        - *n/a*
- City of Toronto
    - Bill Snodgrass
- USA
    - Environmental Protection Agency (EPA)
        - *n/a*
    - United States Geological Survey (USGS)
        - Great Lakes Science Center (GLSC)
            - *n/a*
- New York State
    - Department of Environmental Conservation (DEC)
        - *Janna Lantry*

International Agencies

- International Joint Commission (IJC)
    - *n/a*
- Great Lakes Fishery Commission (GLFC)
    - *n/a*

Non-Governmental Organizations (NGOs)

- The Canadian Aquatic Invasive Species Network (CAISN)

- The Nature Conservancy

- The St. Lawrence River Institute of Environmental Sciences
    - *Jerome Marty*

Universities

- Canada
    - McMaster University
        - *n/a*
    - Queen's University
        - *Leon Bergman*
    - Trent University
        - *Cindy Chu*
    - University of Toronto
        - *Tom Stewart*
    - University of Waterloo
        - *Luis Leon*
        - *Ralph Smith*

- USA
    - Cornell University
        - *Ed Mills*
    - University at Buffalo (SUNY)
        - *J.F. Atkinson*
    - The College at Brockport (SUNY)
        - *Joe Makarewicz*
    - University of Wisconsin
        - *Scott Higgins*

'Emeritus' scientists

- *Ken Minns*
- *Ora Johannsson*

CONCLUSIONS AND RECOMMENDATIONS

The Lake Ontario Ecosystem Research Initiative Work Planning Workshop achieved its aims. It:

- developed a list of issues and stressors affecting the nearshore zone;
- identified current research activities occurring in the nearshore zone;
- identified and reviewed potential research activities to help address the goals of the LO-ERI; and
- developed partnerships for collaborative research and funding.

The workshop recognized the need to define and prioritize both short- and long-term questions to be answered regarding the nearshore zone of Lake Ontario, particularly involving how the nearshore coastal area contributes to the function of the whole lake, the sensitivity of the nearshore to cumulative impacts from multiple stressors, and how the nearshore will respond to projected future conditions.

Recommended follow-up:

- Have the short- and long-term questions been developed and prioritized? Have the potential partners collaborated in this development and prioritization?

The workshop also recognized the need to develop appropriate, shared, classification schemes (e.g., a multi-purpose habitat classification of the nearshore zone), and a shared model of the data needed to answer the above questions about the nearshore zone of Lake Ontario.

Recommended follow-up:

- Have the potential partners worked to develop appropriate shared classification schemes and a model of the data needed to answer the priority questions?

The workshop fostered an atmosphere of cooperation and collaboration towards common goals in researching Lake Ontario's nearshore zone, but recognized that integration of research actvities is an issue.

Recommended follow-up:

- Are the potential partners collaborating to do the right research?

APPENDICES

APPENDIX 1: TERMS OF REFERENCE

Lake Ontario Ecosystem Research Initiative (LO-ERI)
Work Planning Workshop

30-31 March 2009
Holiday Inn Burlington Hotel and Conference Centre, Burlington, ON

Co-chairs: Bob Randall and Marten Koops

Background

The goal of the Lake Ontario ERI is to build on research and partnerships in Lake Ontario to evaluate how the nearshore areas contribute to the function of the whole lake, assess the sensitivity of the nearshore to cumulative impacts from multiple stressors, and predict how the nearshore will respond to projected future conditions.

This will be accomplished through field studies to fill information gaps about the function of the nearshore and its linkages to the offshore, evaluation of ecosystem indicators that assess cumulative impacts of multiple stressors, and modelling to synthesize data and explore scenarios to assess the sensitivity and responses of the nearshore.

The Lake Ontario ERI will help inform decision making on issues related to the management of fish habitat and human development in the Great Lakes, AIS control, and climate change adaptation. The conservation objectives for the Great Lakes are integrated across multiple jurisdictions. The conservation objectives and mandate of DFO are 1) to ensure no-net-loss of habitat productive capacity; 2) to ensure the survival and recovery of species-at-risk; and 3) to support sustainable fisheries and protect biodiversity to fulfill our federal regulatory responsibility for inter-departmental (Transport Canada, Environment Canada), provincial (Canada-Ontario) and international (International Joint Commission and Great Lakes Fishery Commission) agreements. The Lake Ontario ERI, by improving our understanding of the role of the nearshore and its response to climate change scenarios can, for example, provide important information for the management of water levels and human development along the shorelines of the Great Lakes.

Objectives

As part of the work planning for the LO-ERI, this workshop will aim to

- develop a list of issues affecting the nearshore zone of Lake Ontario;
- identify major stressors affecting the coastal zone;
- identify current research activities occurring in the nearshore of Lake Ontario;
- identify potential research activities that will help to address the three goals of the LO-ERI;
- develop partnerships for collaborative research and funding.

Output

A report documenting the workshop proceedings.

Expected Participation

Participants include DFO Central & Arctic Science, and Habitat, Environment Canada, Ontario Ministry of Natural Resources, Ministry of the Environment, and Academia.

APPENDIX 2: PARTICIPANTS LIST

	Name	Affiliation[1]	Days and Group[2]
1	Bob Randall	DFO-GLLFAS	12R
2	Carolyn Bakelaar	DFO-GLLFAS	12S
3	Christine Brousseau	DFO-GLLFAS	12T
4	Cindy Chu	Trent U (DFO)	12S
5	Debbie Ming	DFO-FHM	12N
6	Jerome Marty	St. Lawrence River Institute	12T
7	Jim Hoyle	OMNR	12S
8	Joe Makarewicz	SUNY Brockport	x2N
9	John Fitzsimons	DFO-GLLFAS	12N
10	Keith Weaver	DFO-CHS	12T
11	Kelly Bowen	DFO-GLLFAS	12S
12	Ken Minns	Emeritus	12T
13	Marie-Claire Doyle	EC	12N
14	Marten Koops	DFO-GLLFAS	12R
15	Michel Goguen	DFO-CHS	12N
16	Michelle Wheatley	DFO C&A Science	12S
17	Mohi Munawar	DFO-GLLFAS	12S

[1] Abbreviations are as follows: DFO=Fisheries and Oceans Canada; DFO C&A Science=Central & Arctic Region Science; DFO-CHS=Canadian Hydrographic Service; DFO-FHM=Fish Habitat Management; DFO-GLLFAS=Great Lakes Laboratory of Fisheries and Aquatic Sciences; EC=Environment Canada; MOE=Ontario Ministry of the Environment; OMNR=Ontario Ministry of Natural Resources; SUNY Brockport=State University of New York (The College at Brockport); Trent U=Trent University; U Toronto=University of Toronto; U Waterloo=University of Waterloo.

[2] Codes are as follows: Day 1 ('1' if present or 'x' if absent), Day 2 ('2' or 'x'), Group (letter). A participant in Group N who attended on both days is coded as '12N'; an attendee on the first day only, who did not participate in a breakout group, is '1xx'.

	Name	Affiliation[1]	Days and Group[2]
18	Nick Mandrak	DFO-GLLFAS	12N
19	Ora Johannsson	Emeritus	12N
20	Ralph Smith	U Waterloo	1xx
21	Ram Yerubandi	EC	12S
22	Ron Dermott	DFO-GLLFAS	12T
23	Scott Millard	DFO-GLLFAS	12S
24	Shelly Dunn	DFO-FHM	12T
25	Sue Doka	DFO-GLLFAS	12N
26	Tim Johnson	OMNR	12T
27	Todd Howell	MOE	12S
28	Tom Pratt	DFO-GLLFAS	12T
29	Tom Stewart	OMNR, U Toronto	12N
30	Veronique Hiriart-Baer	EC	1xx
31	Vi Richardson	EC	1xx

[1] Abbreviations are as follows: DFO=Fisheries and Oceans Canada; DFO C&A Science=Central & Arctic Region Science; DFO-CHS=Canadian Hydrographic Service; DFO-FHM=Fish Habitat Management; DFO-GLLFAS=Great Lakes Laboratory of Fisheries and Aquatic Sciences; EC=Environment Canada; MOE=Ontario Ministry of the Environment; OMNR=Ontario Ministry of Natural Resources; SUNY Brockport=State University of New York (The College at Brockport); Trent U=Trent University; U Toronto=University of Toronto; U Waterloo=University of Waterloo.

[1] Codes are as follows: Day 1 ('1' if present or 'x' if absent), Day 2 ('2' or 'x'), Group (letter). A participant in Group N who attended on both days is coded as '12N'; an attendee on the first day only, who did not participate in a breakout group, is '1xx'.

APPENDIX 3: AGENDA

Day 1 – March 30th

13:00 Welcome and Introductions

13:15 Opening Remarks – Michelle Wheatley

- Context: what is DFO trying to do with the ERIs?

Presentations on Current Lake Ontario Nearshore Activities and Issues

- *What are the current issues and stressors?*
- *What are the current research activities?*
- *What are the knowledge gaps?*

13:30 Lake Ontario Circulation Modelling – Ram Yerubandi

13:50 Lake Ontario Coastal Zone Status and Assessment (LOLA 2008) – Todd Howell

14:10 Nearshore Planktonic Foodweb of Lake Ontario: Changes and Implications – Mohi Munawar

14:30 Nearshore AIS Research and Monitoring – Kelly Bowen, Christine Brousseau

14:50 Health Break

15:20 Nearshore Fish Communities Index Netting on Lake Ontario – Jim Hoyle

15:40 Water Levels, Climate Change, and Nearshore Fishes – Sue Doka

16:00 Nearshore Species at Risk Research – Tom Pratt

16:20 Nearshore Contributions to Offshore Fishes – Tom Stewart

17:00 Adjourn Day 1

Day 2 – March 31st

09:00 Brief Re-Cap of Day 1

09:10 Coastal Zone Management in U.S. Waters of the Great Lakes – Joe Makarewicz

09:30 Fish Habitat Management Nearshore Issues – Debbie Ming

09:50 Health Break

Break-out Groups

10:20 Direction to break-out groups

10:30 Group discussions of the following (3 groups):

- Have we missed any ongoing nearshore activities or issues?
- What are the most important knowledge gaps concerning the nearshore of Lake Ontario? Why?

11:30 Plenary report on morning discussions

12:00 Lunch (provided)

13:00 Synthesis and discussion of knowledge gaps

Presentation on LO-ERI

13:30 What is the Lake Ontario Ecosystem Research Initiative (LO-ERI)? – Bob Randall, Marten Koops

- Objectives of LO-ERI
- Initial scoping of LO-ERI activities

Break-out Groups

14:00 Group discussions (3 groups):

- Will the scoped activities meet the LO-ERI objectives?
- Given the scoped LO-ERI activities, are there key knowledge gaps that are still not being addressed?
- Do the scoped activities overlap with other ongoing activities?
- Are there opportunities to partner? Funding?

15:00 Health Break

15:30 Plenary Reports & **Discussion**

16:30 Adjourn

APPENDIX 4: BREAK-PUT QUESTIONS

Break-out 1 – Current Lake Ontario Nearshore Issues, Activities and Knowledge Gaps

1. Are there any issues or activities relevant to the nearshore of Lake Ontario that have not been identified? If yes, what are they?
2. Are there important knowledge gaps that have not yet been identified? If yes, what are they?
3. Given the knowledge gaps identified in the presentations and when answering the above question, which are the most important knowledge gaps concerning the nearshore of Lake Ontario? Why?

Break-out 2 – Lake Ontario Ecosystem Research Initiative (LO-ERI)

The goal of the Lake Ontario ERI is to build on research and partnerships in Lake Ontario to

- i. evaluate how the nearshore areas contribute to the function of the whole lake,
- ii. assess the sensitivity of the nearshore to cumulative impacts from multiple stressors, and
- iii. predict how the nearshore will respond to projected future conditions.

1. Will all the described activities meet the LO-ERI objectives?
2. Do any of these activities overlap with other ongoing activities?
3. If all the proposed LO-ERI activities are performed, are there key knowledge gaps that will still not be addressed? If yes, which gaps? How might the LO-ERI contribute to filling these knowledge gaps?
4. Are there opportunities to partner?

APPENDIX 5: ACRONYMS AND OTHER SHORT FORMS

Acronym/Short Form	Meaning
AOC	Area of Concern (under the Great Lakes Water Quality Agreement)
ADCP	Acoustic Doppler Current Profiler (measures water velocity at depths)
AIS	aquatic invasive species
C&A	Central & Arctic Region (DFO)
CA	a Conservation Authority
CAHR	Centre for Aquatic Habitat Research
CAISN	Canadian Aquatic Invasive Species Network
CANDIE	Canadian version of DieCAST
CBL	coastal boundary layer (of a lake)
CDOM	coloured dissolved organic matter
CEAA	Canadian Environmental Assessment Act
CEARA	Centre of Expertise for Aquatic Risk Assessment
CHIF	Centre of Expertise on Hydropower Impacts on Fish and Fish Habitat
CHS	Canadian Hydrographic Service (DFO)
CLOCA	Central Lake Ontario Conservation Authority
CoE	Centre of Excellence
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CVC	Credit Valley Conservation (a CA)
DEC	Department of Environmental Conservation (New York State)
DieCAST	Dietrich Center for Air Sea Technology model (an ocean model)
DOC	dissolved organic carbon
DOM	dissolved organic matter (in the water)
DFO	(Department of) Fisheries and Oceans Canada
EBA	ecosystem-based approach

Acronym/Short Form	Meaning
EC	Environment Canada
ELCOM	Estuary Lake Computer Model
EPA	(US) Environmental Protection Agency
ERI	Ecosystem Research Initiative
ESA	Endangered Species Act (Ontario)
FBL	frictional boundary layer (of a lake)
FHM	Fish Habitat Management (DFO)
GLAP	Great Lakes Action Plan
GLERL	Great Lakes Environmental Research Laboratory (referenced in the Donelan/GLERL wave model)
GLFC	Great Lakes Fishery Commission
GLLFAS	Great Lakes Laboratory for Fisheries and Aquatic Sciences (DFO)
GLSC	Great Lakes Science Center (USGS)
GRCA	Ganaraska Region Conservation Authority
HAB	harmful algal bloom
HADD	harmful alteration, disruption, or destruction of fish habitat
HRCA	Conservation Halton (aka Halton Region Conservation Authority)
HWM	high water mark
IBL	inertial boundary layer (of a lake)
IJC	International Joint Commission
LO-ERI	Lake Ontario Ecosystem Research Initiative
LOA	Letter of Advice (from DFO, re work in or around water)
LOLA	Lake Ontario Lower Aquatic Food Web Assessment
LONNS	Lake Ontario Nearshore Nutrient Study
MNR, OMNR	Ontario Ministry of Natural Resources

Acronym/Short Form	Meaning
MOE	Ontario Ministry of the Environment
NGO	Non-Governmental Organization
NPCA	Niagara Peninsula Conservation Authority
NSCIN	Nearshore Community Index Netting
OGLA	Ontario-Great Lakes Area (an organization unit within DFO)
OMNR, MNR	Ontario Ministry of Natural Resources
OPG	Ontario Power Generation
P/B	production/biomass ratio (e.g., of zooplankton)
PAR	photosynthetically active radiation (a measurement of light in water)
PCA	Parks Canada Agency
POM	particulate organic matter (in the water)
POM	Princeton Ocean Model
RBG	Royal Botanical Gardens
SAR	species at risk
SARA	Species at Risk Act (Canada)
SRP	soluble reactive phosphorus-phosphate
STP	sewage treatment plant
SUNY	State University of New York
TKN	total Kjeldahl nitrogen
TP	total phosphorus
TRCA	Toronto and Region Conservation Authority
TSS	total suspended solids
USGS	United States Geological Survey
UV	ultra-violet