CHAPTER 10 SIGNIFICANT ONGOING AND EMERGING ISSUES

10.1 Summary

This section provides insight into some of the significant ongoing and emerging issues facing Lake Ontario including: invasive species; fish and wildlife disease issues; Type E botulism; emerging chemicals of concern; lake levels; rapid urbanization and toxin-producing planktonic blooms. Some of the issues are ongoing, and have been the subject of much research and reporting, while others are newer issues that may present challenges for the Lake Ontario LaMP and lake managers in future. The material presented is based on information that existed as of October 2005.

10.2 Significant Ongoing Issues

This section provides a brief description of significant ongoing lakewide issues and provides an update on their status and progress.

10.2.1 Protection and Restoration of Native Species

Lake Trout

One of the key restoration components of the lake trout indicator (see Chapter 3) is reducing mortality so that the adult population can reach a level promoting self-sustenance. Lake trout are preyed upon by sea lamprey and presumably their eggs are consumed by round goby. The abundance of sea lamprey is controlled by the US Fish and Wildlife Service and Canada’s Department of Fisheries and Oceans and the entire control program is managed by the Great Lakes Fishery Commission (GLFC). Currently this program is meeting its control targets and sea lamprey are not presently considered a major limiting factor in lake trout restoration. But, sea lamprey control is a perpetual source of mortality and is a significant annual cost to both federal governments directly and to provincial, state and federal governments indirectly due to loss of recreationally important fish.

American Eel

American eel are an important component of the biodiversity of Lake Ontario and the St. Lawrence River and were once a very abundant top predator throughout much of these waters. The numbers of eels migrating upstream of the power dam at Cornwall and into Lake Ontario have declined so precipitously that American eels may be extirpated from this part of their range. This near shore top predator remains in Lake Ontario for up to 14 years and then returns to spawn in the Sargasso Sea. The Lake Ontario portion of the population is composed entirely of female fish and they are among the largest and most fecund. The American eel is doing so poorly in its entire range that efforts are underway in both Canada and the US to provide additional protection for this species and aid in their rehabilitation.

The Lake Ontario LaMP agencies will continue to work with stakeholders such as the hydro-electric power companies that operate dams on the St. Lawrence River to restore abundance of this important species in the upper St. Lawrence River and Lake Ontario. Some examples of recent actions include, closure of the commercial fishery for eels in Ontario, reductions to fishing in Quebec, eel stocking in Lake Champlain, decision analysis on alternative approaches to encourage safe eel migration in the St. Lawrence River, and research projects in both Canada and the U.S. into improving our ability to manage eel.

10.2.2 Invasive Species

An invasive species is defined as a species that is non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. Invasive species in the Great Lakes may occur in riparian areas, tributaries, and in nearshore and open waters. Impacts of invasive species include environmental (predation, parasitism, competition, introduction of new pathogens, genetic, and habitat alterations), economic (industrial water users, municipal water supplies, nuclear power plants, commercial and recreational fishing, and other water sports), and public health concerns (pathogens).

Since the early 1800s at least 162 new organisms have been introduced into the Great Lakes (Ricciardi 2001, Mills et al. 1993). Approximately 10 per cent of these species have had demonstrably substantial impacts on the Great Lakes (Mills et al. 1993). Methods of introduction include deliberate release, unintentional release (i.e. aquarium, escape from cultivation or aquaculture, bait bucket, and with stocked fish), from shipping activities, canals, and railroads and highways. Shipping activities followed by unintentional release have been the major vectors of introduction into the Great Lakes (Mills et al. 1993).

It is difficult to predict some of the more subtle interactions that might develop between newly introduced non-native species, naturalized non-native species, and native species. This evaluation is further complicated by other chemical and physical changes that are taking place in the basin concurrently. It is clear, however, that non-native species have had a significant impact on the Lake Ontario ecosystem and continue to do so. The Lake Ontario ecosystem has experienced several significant impacts by non-native species, some of which are discussed in Chapter 2 and Chapter 4, section 4.4.6, (degradation of fish populations). Some of the key invasive species impacting the Lake Ontario ecosystem are highlighted below (also see section 4.4.3). Other non-native species that are causing or are likely to cause economic or environmental harm in Lake Ontario are listed in Table 10.1.

Table 10.1 Other non native species threatening Lake Ontario ecosystem, their origin, date and location of first sighting, mechanism of introduction into the Great Lakes, and their current or potential impacts. (Dermot and Legner 2002, Mills et al. 1993, Owens et al. 1998, Ricciardi 2001, Witt et al. 1997, and Zaranko et al. 1997)

Common Name & Species	Type	Origin	Date and Location of First Sighting	Mechanism	Impacts
Rudd Scardinius erythrophthalmus	fish	Eurasia	1989 - Lake Ontario	Bait bucket release	Compete w/native species
Blueback herring Alosa aestivalis	fish	Atlantic N. Amer.	1995 - Lake Ontario	Canals	Impede recovery of native fishes
Eurasian ruffe Gymnocephalus cernuus	fish	Eurasia	1986 - St. Louis River, Lake Superior[1]	Shipping (ballast water)	Compete w/native species
New Zealand mud snail Potamopyrgus antipodarum	benthic inverte-brate	New Zealand	1991 - SW Lake Ontario	Shipping (ballast water)	Clog water intakes, compete w/native species
Amphipod Echinogammarus ischnus	benthic inverte-brate	Black Sea	1995 - Detroit River[2]	Shipping (ballast water)	Displacing native species
Eurasian watermilfoil Myriophyllum spicatum	plant	Eurasia	1952 - Lake Erie 1960 - S. Lake Ontario	Release (aquarium, accidental)	Clogs waterways, compete w/native species
European frogbit Hydrocharis morsus-ranae	plant	Eurasia	1972 - Lake Ontario	Release (Aquarium, Deliberate), Shipping (Fouling)	Clogs waterways, compete w/native species

Table 10.1 Other non native species threatening Lake Ontario ecosystem, their origin, date and location of first sighting, mechanism of introduction into the Great Lakes, and their current or potential impacts. (Dermot and Legner 2002, Mills et al. 1993, Owens et al. 1998, Ricciardi 2001, Witt et al. 1997, and Zaranko et al. 1997)

Common Name & Species	Type	Origin	Date and Location of First Sighting	Mechanism	Impacts
Water chestnut Trapa natans	plant	Eurasia	<1959 - Lake Ontario tributaries	Release (aquarium, accidental)	Clogs waterways, compete w/native species
Filamentous bacteria *Thioploca ingrica*	bacteria	Europe Japan S. Amer.	1999 - Eastern Lake Ontario	Unknown	May reduce energy flow from benthic to pelagic communities

1. Not presently in Lake Ontario.
2. Has spread downstream into SW Lake Ontario.

Zebra and Quagga Mussels

Zebra mussels (*Driessena polymorpha*) were first discovered in Lakes St. Clair and Erie in 1988. Their introduction into the Great Lakes likely occurred in 1985 or 1986 when one or more transoceanic ships from Europe discharged ballast water into Lake St. Clair. Quagga mussels (*D. bugensis*) were first discovered in the early 1990s in Lakes Ontario and Erie. Both species have since proliferated throughout the Great Lakes and beyond by natural spread of their planktonic veliger larvae, transported as microscopic veligers in water pockets on boats or in aquatic weeds attached to boat trailers, and as adults attached to boat hulls. Maximum out-of-water survival is about 10 days for adults and three days for newly settled juveniles.

The zebra and quagga mussels have impacted the Great Lakes both economically and ecologically. It is estimated that they cause $500 million per year in economic impacts to tourism, electric power plants, public water supplies, commercial fishing, sport fishing, boating, and transport industries (Pimentel 2005). Zebra and quagga mussel infestations cause pronounced ecological changes in the Great Lakes and major rivers of the central United States. Their rapid reproduction in combination with their high consumption of microscopic plants and animals affects the aquatic food web and places valuable commercial and sport fisheries at risk. These two species of mussels filter water to feed on microscopic phytoplankton and other organic material, thereby reducing the amount of food available to other filter feeding organisms. The filtering action of the mussels has contributed to the dramatic improvements in water clarity. It is anticipated that reductions in phytoplankton densities due to zebra and quagga mussel filtering may result in smaller zooplankton populations. Zebra and quagga mussels cover large areas of the bottom of Lake Ontario. Their presence on the bottom surface of the lake has dramatically altered the habitat making it less suitable for some native invertebrates. Populations of many native benthic organisms have generally declined, most notably the burrowing amphipod *Diporeia*. The reduction of *Diporeia* is expected to have a significant impact on fish species that depend on it for their growth and survival.

Fishhook and Spiny Waterfleas

The spiny waterflea (*Bythotrephes longimanus*) was first introduced in Lake Huron in 1984 and found in Lake Ontario by 1985. The fishhook waterflea (*Cercopagis pengoi*) was first found in Lake Ontario in 1998. These two related zooplankton species also arrived in transoceanic ships' ballast from Eurasia. The first noticeable impact of these species was on recreational fishing. The tail spines of both fishhook and spiny waterfleas hook on fishing lines, fouling fishing gear. The spiny waterflea has never been very common in Lake Ontario, whereas the fishhook waterflea is found throughout the lake. Both the fishhook flea and the spiny water flea are large zooplankton that feed on smaller native zooplankton. There is evidence that the fishhook waterflea predation on small zooplankton has caused decreased juvenile copepod production and changed their vertical distribution. There is evidence that small young-of-the-year fish are not able to feed on these waterfleas due to their long tail spines, but larger planktivorous fish do eat them. The long-term impacts to the fish community are unknown.

Round Goby

The round goby (*Neogobius melanostomus*), first discovered in the St. Clair River in 1990, has spread rapidly throughout the Great Lakes. It was first sighted in Lake Ontario in 1998 and is now found in many areas of the lake. This bottom dwelling fish is native to Eurasia, and was introduced through the release of ballast water of transoceanic ships from Europe. The round goby has established itself in the nearshore and is colonizing offshore waters to depths greater than 120 m (394 ft.) and in association with quagga mussels. This benthic fish feeds primarily on *Dreissena spp.* but early life stages compete with other young fish for zooplankton, veligers, and other small food items. The round goby can displace native bottom dwelling fish such as sculpin. They will feed on fish eggs and young fish, take over optimal habitat, spawn multiple times in a season, and survive in poor quality water, thus giving them a competitive edge over our native fish. Research on Lake Erie suggests that round gobies are important fish to the upper food web as they redirect energy tied up in *Dreissena* to fish that eat goby. There is the potential for redistribution of contaminants to the pelagic fishes via round gobies. Their spread into some areas of Lakes Erie and Ontario has been followed by outbreaks of botulism in fish and birds, leading to speculation that round goby may be playing a role in these outbreaks.

Asian Carps

There are four species of Asian carp introduced into North America which pose a potential threat to the ecology of the Great Lakes. These are commonly referred to as grass carp, bighead carp, silver carp and black carp. Grass carp have been widely introduced to control aquatic vegetation and are reproducing naturally in many areas of the United States (Cudmore and Mandrak 2004). Bighead and silver carps were brought into aquaculture facilities as a food fish and for controlling plankton blooms. These two species have escaped into nearby natural waters, and are currently reproducing throughout most of the Mississippi River basin (Mandrak and Cudmore 2004). Black carp are used in aquaculture facilities for controlling snails and a few individuals have escaped into natural waters. Natural reproduction of this species has not yet been confirmed (Mandrak and Cudmore 2004).

In the Great Lakes basin, only a few individuals of grass and bighead carps have been reported. Grass carp has been collected from the Lake Ontario watershed and bighead carp have been collected from Lake Erie (Mandrak and Cudmore 2004, Morrison et al. 2004). A bighead carp was also found in a fountain on University Avenue in Toronto in 1991 (Mandrak and Cudmore 2004). To date, there is no evidence of reproduction in the lower Great Lakes and it is suspected that these individuals originated from live food fish markets in the Greater Toronto Area. Only grass and bighead carps are recorded from the live food fish markets. However, a silver carp (not listed on imported records from the Canadian Food Inspection Agency) was identified in a tank in one of these markets in 2004 (Mandrak and Cudmore 2004). Silver and bighead carp have been collected in the Illinois River which is connected with Lake Michigan via the Chicago Sanitary and Ship Canal. An electrical barrier system is being installed in the canal in an attempt to block this path into the Great Lakes; although concern regarding potential egg drift has been raised.

Known ecological risks of Asian carps from their potential rapid range expansion and population increase include habitat alteration and disruption of the Great Lakes food web at most trophic levels (Mandrak and Cudmore 2004). Grass carp can eliminate vast areas of aquatic plants that are important as fish food and spawning and nursery habitats, which could potentially reduce recruitment and abundance of native fishes. Bighead and silver carps already make up more than 80 per cent of the biomass in many areas in the Mississippi River basin, out competing native fishes for food and space (Mandrak and Cudmore 2004). Silver carp have the ability to jump up to 10 feet (3 m) out of the water, a behavior which has resulted in injuries to boaters. Black carp could reduce abundance and diversity of already rare mollusks.

Current Activities/Legislation to prevent further introductions

The Lake Ontario LaMP partner agencies are working with many groups on international, national and local-level invasive species management activities and share information and new techniques for fighting invasive species. Prevention, detection and monitoring, and control and management are key components of many programs. Preventing introductions and further spread of invasive species is occurring through legislative and regulatory actions, and public outreach and education.

Ballast Water Control

The international community recognized that uncontrolled discharge of ballast water and sediment has been the leading method of transfer of harmful aquatic organisms and pathogens into the Great Lakes. The United Nations International Maritime Organization (IMO) has been addressing the issue since 1988, and adopted voluntary guidelines in 1991 to help prevent further introductions. In response to national concern regarding aquatic invasive species, the National Invasive Species Act of 1996 (NISA) was enacted within the United States which reauthorized and amended the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA). NISA required the Coast Guard to establish national voluntary ballast water management guidelines. If the guidelines were deemed inadequate, NISA directed the Coast Guard to convert them into a mandatory national program. Voluntary ballast water management was initiated in 1998. However, the rate of compliance was found to be inadequate, and the voluntary program became mandatory on July 28, 2004. In Canada, voluntary ballast water control measures were established in Transport Canada Publication TP 13617, Guidelines for the Control of Ballast Water Discharge from Ships in Waters under Canadian Jurisdiction (TP 13617), in 2001 as part of the Canada Shipping Act.

It is expected that Canadian Regulations to control ballast water will be promulgated in 2006. In June 2005, the *Ballast Water Control Management Regulations* were posted in the Canada Gazette (Vol. 139, No. 24 — June 11, 20) for a 75 day public comment period. The proposed Regulations are made pursuant to the Canada Shipping Act (S. 657.1). The purpose of the proposed Regulations is to require ships to manage ballast water in such a manner as to reduce the potential for the release of invasive (exotic) species in Canadian waters. The regulations will make several of the existing voluntary measures outlined in TP 13617 mandatory for all ships designed to carry ballast water that enter waters under Canadian jurisdiction. The proposed Regulations are harmonized as much as possible with the United States' rule for ballast water management and with the International Convention for the Control and Management of Ships' Ballast Water and Sediments.

Neither the international convention, proposed Canadian Regulations or U.S. legislation provide specific requirements or procedures that address ships that have no ballast on board (NOBOB). Both Transport Canada and the US Coast Guard are both jointly working on a solution to the NOBOB issue. Both countries' regulations require open ocean ballast water exchange for all vessels entering the US or Canada from outside the Exclusive Economic Zone (EEZ), but not for vessels operating inside the EEZ. The regulations also allow for alternative treatment methods, and require ballast water management plans and record books for each vessel. The Lake Ontario LaMP will continue to follow the development of ballast water control.

Prohibition of the Sale of Live Fish

The province of Ontario has recently passed legislation prohibiting the possession and sale of live individuals of the four Asian carp species, snakeheads and the round and tubenose goby. Therefore, it is illegal for these species to be sold in the live food fish, aquarium or bait trades. New York has a statewide ban on the possession of three live species of Asian carp (Bighead, Silver and Black) and all species of live snakeheads, and their eggs, with an exemption for allowing live bighead carp for retail sale purposes in limited sections of New York City. Although bighead carp may be maintained live for retail purposes, they must be killed at the time of sale to prevent further transport and distribution within the state. The live food fish markets do pose a potential source for release of live invasive species, despite prohibitions for certain listed species. Species not included in the prohibitions include swamp eel and marbled goby.

Education and Outreach

The LaMP agencies, other governmental agencies and NGOs are all involved with various education and outreach activities. Posters and brochures, watch cards and stickers have been developed to help identify and prevent the unintentional introduction or spread of invasive species. "Habitattitude" is a national initiative in the US developed by the Aquatic Nuisance Species Task Force and its partner organizations educating aquarium hobbyists, backyard pond owners and water gardeners about protecting the environment from unintentional introductions (http://www.habitattitude.net). Aquatic Invasive Species Hazard Analysis and Critical Control Point (AIS-HACCP) is a system to reduce or prevent the spread of unwanted species into new water bodies. This training is targeted for baitfish and aquaculture operators, fish managers and researchers, and enforcement officers. AIS-HACCP training is available through various agencies including the US Fish and Wildlife Service and Sea Grant.

In 1992 the Ontario Federation of Anglers and Hunters, in partnership with the Ontario Ministry of Natural Resources, established The Invading Species Awareness Program (http://www.invadingspecies.com/). The objectives of this program are to raise public awareness of invasive species and encourage their participation in preventing their spread; monitor and track the spread of invading species in Ontario waters through citizen reports to the Invading Species Hotline and the Invading Species Watch program; and conduct research on the impacts and control of invasive species.

The Ontario Ministry of Natural Resources also provides publicly accessible information on their website (http://www.mnr.gov.on.ca/MNR/fishing/threat.html) to inform and assist the public in identifying and taking proper action to help prevent spread of invasive species.

Other Initiatives

Within Canada the federal government has initiated the development of a national aquatic invasive species program consistent with the *Canadian Action Plan to Address the Threat of Aquatic Invasive Species* approved by the Canadian Council of Fisheries and Aquaculture Ministers in September 2004. Activities will support the highest priority areas: prevention, early detection, and rapid response. This initiative will include the Lake Ontario and Great Lakes basins.

10.2.3 Lake Ontario Water Levels

Artificial control of the Lake Ontario water levels threatens the natural ecosystem through the alteration of wetland plant communities and habitat quality.

The LaMP has determined that fish and wildlife habitat are impaired on a lakewide scale due to the artificial management of lake levels. Since 1960, Lake Ontario's water level has been regulated based on criteria set by the IJC in 1956 (available at www.losl.org). Water levels are determined by the IJC under a formula that seeks to balance a number of interests and are controlled by a series of dams on the St. Lawrence River (IJC Lake Ontario Regulation 1958D (see Section 4.4.3)). Many biologists believe that water level regulation has had serious and lasting impacts on Lake Ontario's natural resources including fish and wildlife (particularly shorebirds and spawning fish), shoreline habitat and dune barrier systems, and the numerous wetland complexes that line the shoreline. The full range of these impacts, however, has never been documented.

The artificial control of lake level affects water level changes in coastal wetlands and dune areas. This change can be a threat to natural ecosystems through the alteration of wetland plant communities and habitat quality. In addition, throughout Lake Ontario, water level regulation is a major stress on remaining wetlands. More variable water levels can lead to greater diversity of wetland plant communities and improve fish and wildlife habitat.

In 2000, the International Joint Commission initiated the International Lake Ontario - St. Lawrence River Study to examine the effects of water level and flow variations on all users and interest groups and determine if better regulation were possible at the existing structures controlling Lake Ontario outflows. A five-year study was undertaken by the International Lake Ontario - St. Lawrence River Study Board (Study Board) to identify and evaluate how changes to current Lake Ontario regulation will affect the interests of various users, while ensuring that any suggested changes are consistent with relevant treaties and agreements between Canada and the United States. The Study Board is in the final year of this comprehensive study. The Study Team engaged by the IJC is a binational group of diverse experts from government, academia, native communities, and interest groups representing the geographical, scientific and community concerns of the Lake Ontario - St. Lawrence River system (see Section 8.2.2 Lake Ontario - St. Lawrence River Study).

The Study Board evaluated the impacts of changing water levels on shore-line communities, domestic and industrial water users, commercial navigation, hydropower production, the environment, and recreational boating and tourism. The evaluation also took into account the forecasted effects of climate change. From this work the Study Board developed three candidate Water Level Plans which best met the Study's Guiding Principles and which will be presented through public consultation for consideration. These plans are: Plan A - a balanced economic plan; Plan B - a balanced environmental plan; and Plan C - a plan with blended economic and environmental benefits.

In response to the three proposed Plans, the Lake Ontario LaMP has communicated to the Study Board US and Canadian Co-Directors that "the restoration of more natural ranges and long term patterns of lake level fluctuations is one of the LaMP's priorities and is perhaps the single greatest opportunity to truly restore more natural functioning to Lake Ontario's ecosystem. For this reason the "Environmentally Balanced" Plan B (as summarized in the LOSL Study's June 2005 Ripple Effects public fact sheet) is the most reflective of a management approach that would support the LaMP's goal of restoring more natural hydrologic conditions to coastal wetlands.

The Lake Ontario LaMP also stated to the Study Board Co-Directors that the selection of a final plan should be viewed as the first step in the process of improving water level management for Lake Ontario. The Study Board should recommend that the IJC consider using an adaptive management approach, coupled with a strong monitoring program and wetland conservation actions, to ensure that the selected plan is achieving its desired environmental goals.

The LaMP will continue to work with the IJC to restore, to the maximum extent possible, the natural functioning of the Lake Ontario ecosystem.

10.3 Emerging Issues

Emerging Issues are those issues that are relatively new to Lake Ontario and may warrant the LaMP's attention. For many of the emerging issues discussed below it is unclear if they pose a threat to the lakewide ecosystem. For this reason the LaMP will track each of these issues and as more information is accumulated the LaMP will assess and determine whether there is a need to develop and coordinate binational actions to address them.

10.3.1 Rapid Urbanization of the Canadian Side of Western Lake Ontario

Land use and population growth in the Greater Toronto Area are impacting Lake Ontario and the stress is growing.

The western end of Lake Ontario (a region commonly known as the Golden Horseshoe) is rapidly urbanizing. It is projected that the region's population will grow from 7.4 million in 2000 to 10.5 million in 2031- an increase of 43 per cent. In fact, this is the third fastest growing area in North America and one of the top 10 most sprawling regions in the world. It is projected that more than 1000 square kilometers of land in this area will be urbanized- most of it prime agricultural land. This is almost double the area of the City of Toronto and represents a 45 per cent increase in the amount of urbanized land in the region.

At issue is not only the absolute growth in population, but the nature of that growth. The fringe development is sprawling- consuming 2 to 3 times more land per person than neighborhoods in the old City of Toronto, which were built prior to World War 2. The large quantities of land consumed per person through urbanization has resulted in increases in the amount of impervious land area, increases in vehicular travel and transportation related emissions and increases in stormwater runoff.

Urbanization radically alters an area's hydrologic regime. There is a strong negative relationship between urban stream quality and impervious cover- the more impervious the land area, the greater the level of stream impairment. A review of the literature has shown that less than 10 per cent imperviousness in an urbanizing watershed is required to maintain stream water quality and quantity, and preserve aquatic species density and biodiversity. An upper limit of 30 per cent has been found to be a threshold for degraded streams

Urbanization also creates a "hidden supply issue." While increasing the relative contribution to surface water bodies from wastewater discharges- groundwater recharge rates decline due to more imperviousness, storm drains and other urban infrastructure.

Two-thirds of coastal wetlands have been lost and those that remain are disturbed. The average size of woodlands is getting smaller and woodlands are being fragmented by roads, utility corridors and housing. This fragmentation is a serious concern when it comes to securing ecosystem function and maintaining at least 30 per cent of our watersheds in natural cover. Overall, ecological conditions in the watersheds of the Golden Horseshoe are degraded and slowly getting worse.

The Province of Ontario has introduced the Greenbelt Act, 2005 which enables the creation of a Greenbelt Plan to protect about 1.8 million acres of environmentally sensitive and agricultural land in the Golden Horseshoe (western Lake Ontario) from urban development and sprawl (see Figure 10.1). It includes and builds on about 800,000 acres of land within the Niagara Escarpment Plan and the Oak Ridges Moraine Conservation Plan.

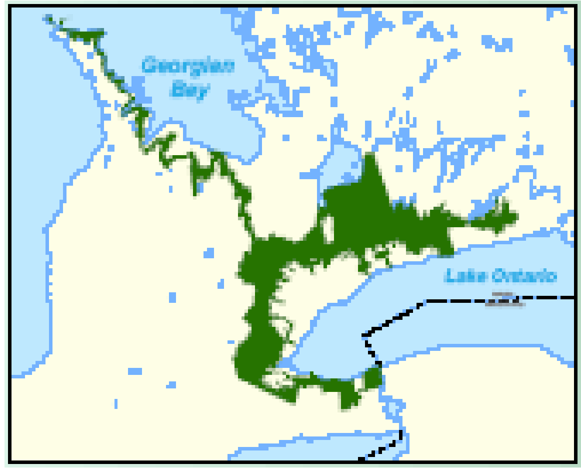

Figure 10.1 Greenbelt Plan Area

10.3.2 Emerging Chemicals of Concern

In addition to pursuing the elimination of critical pollutant inputs, the LaMP tracks information on other bioaccumulative contaminants and encourages member institutions to contribute the collection of information for possible assessment. The LaMP continues to monitor, support, and evaluate scientific investigations into other bioaccumulative or toxic contaminants that may cause lakewide impairments. There are several classes of compounds that have attracted the attention of academic and government research and monitoring programs in the Great Lakes region. In Lake Ontario, a number of recent studies have been presented or are underway, either through the participation or funding by LaMP agencies, on the occurrence and temporal trends of emerging and other chemicals of concern. These include studies on brominated flame retardants, particularly polybrominated diphenyl ethers (PBDEs), perfluorinated compounds, and polychlorinated naphthalenes (PCNs).

Flame Retardants

Studies of brominated flame retardants have focused on PBDEs, however others are in wide use, including hexabromocyclododecane (HBCD) and tetrabromobisphenol A (TBBPA), while others are coming on the market as potential PBDE replacements.

Polybrominated diphenyl ethers (PBDEs)

Polybrominated diphenyl ethers are a class of bioaccumulative chemicals that have been widely used over the last two decades as flame retardant in textiles, polyurethane foam, acrylonitrile butadiene styrene plastic (ABS), building materials, and electrical components such as computers and televisions. These materials can contain between 5 to 30 per cent PBDE by weight, greatly reducing risks due to fires. PBDEs have been manufactured primarily as three mixtures, the penta-mix (PBDEs with 4-6 bromines per molecule), the octa-mix (6-10 bromines) and the deca-mix (10 bromines). Unfortunately, PBDEs are also highly mobile in the environment and are now recognized as a globally persistent organic pollutant found even in the marine foodweb of remote Arctic regions.

Concentrations of PBDEs have increased dramatically in the Great Lakes system. Monitoring studies conducted in Lake Ontario have shown exponential increases in PBDE concentrations with time in archived eggs of herring gulls (Norstrom et al., 2002), in lake trout tissues (Zhu & Hites, 2004), and in dated sediment cores (Song et al., 2005). Results of other studies (e.g. Luross et al., 2002) suggest that local emissions from large urban/industrial areas are the major sources.

A number of uncertainties remain for PBDEs in the Great Lakes region with respect to the magnitude of the various sources to the environment, their fate, and their potential for effects on humans and wildlife. As a result, there are currently no water quality or fish tissue criteria for PBDEs.

A number of recent actions by governments and industry in Canada and the US to address PBDEs include:

- November 2003: The Great Lakes Chemical Corporation, the only manufacturer of PBDEs in the US, agreed to voluntarily phase-out PBDE (penta- and octa-BDE products) production by December 31, 2004

- May 2004: Environment Canada and Health Canada published a screening assessment that concluded that PBDEs are "toxic" under the Canadian Environmental Protection Act, 1999. This assessment relied, in part, on data generated through the LaMP for Lake Ontario surface water concentrations.

- December 2004: USEPA issued a draft "Significant New Use Rule" under the Toxic Substances Control Act for two of the three major commercial PBDE products. The draft rule would require manufacturers and importers to notify EPA at least 90 days before commencing the manufacture or import of these PBDEs.

- August 2004: The manufacture, process or distribution of brominated flame retardants was prohibited within the New York State under Section 37-0111 of the New York State Laws.

- The USEPA Great Lakes National Program Office (GLNPO) has recently added flame retardants (e.g. PBDEs) and two other classes of chemicals, PCNs and PFOS (perfluorooctane sulfonate), to its list of organic contaminants that are routinely monitored for under the Great Lakes Fish Monitoring Program.

Hexabromocyclododecane (HBCD)

Hexabromocyclododecane (HBCD) is another brominated flame retardant consisting of three cycloaliphatic isomers (α-, β- and γ- isomers). Like PBDEs, these are additive flame retardants widely used in extruded and expanded polystyrene foam insulation but also used in textiles. The manufacture and use of HBCD is thought to be increasing in recent years as these are likely replacements of PBDEs in some applications as the latter are phased out. However, HBCD has an estimated logarithm of the octanol-water partition coefficient (log K_{OW}) of 5.6 indicating that HBCD may bioaccumulate.

A recent study of the Lake Ontario food web (plankton-invertebrates-forage fish-lake trout) has shown that HBCD biomagnifies to a similar extent as p,p'-DDE and total PCBs (Tomy et al., 2004). Very little is known about the long term persistence and potential toxicity of these compounds.

Perfluorinated Compounds

Perfluorinated compounds such as perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) and their precursors are used in a broad range of applications including fire-fighting foams, surface coatings in textiles and carpeting, and in fluoropolymer formulations. These compounds are found throughout the global environment, including remote arctic regions. They are very stable in the environment and PFOS has been found to bioaccumulate.

Studies on these compounds have been conducted in Lake Ontario. PFOS has been found to biomagnify in the Lake Ontario food web (plankton-invertebrates-forage fish-lake trout) while PFOA does not seem to biomagnify (Martin et al., 2004). Perfluorinated carboxylic acids with carbon chains longer than PFOA do biomagnify. An increasing trend in PFOS concentrations in lake trout was found for the period between 1980 and 2001 (Martin et al., 2004). PFOS and PFOA were reported in Lake Ontario surface waters (Boulanger et al., 2004) and a preliminary mass balance model suggests that, besides inputs from upstream (Niagara River and Lake Erie), sewage treatment plant effluents are major sources to Lake Ontario (Boulanger et al., 2005).

The fate and distribution of these chemicals in the environment, and the identification of primary sources (i.e. degradation products, residuals from products, or direct releases) remain topics of study.

Recent actions:

- May 2000: 3M voluntarily stops production and use of PFOS (e.g. in Scotchgard™)

- October 2004: Environment Canada and Health Canada publish, for public comment, the draft Screening Assessment on Perfluorooctane Sulfonate, Its Salts and Its Precursors, proposing that PFOS, its salts and its precursors be considered "toxic" under the *Canadian Environmental Protection Act, 1999*.

- January 2005: USEPA released for public comment, the draft Risk Assessment of the Potential Human Health Effects Associated with Exposure to Perfluorooctanoic acid and its salts (PFOA).

Polychlorinated Naphthalenes (PCNs)

Polychlorinated naphthalenes (PCNs) are persistent, bioaccumulative compounds which exhibit dioxin-like toxicity. PCNs were used as dielectrics for flame resistance and insulation in capacitors and cables, are trace contaminants in PCB mixtures, and are produced in combustion emissions. The sources of these compounds to the Great Lakes was the past use of products containing Halowax mixtures and their subsequent disposal, industrial discharges from production and use, chlor-alkali production, PCB usage, and combustion from sources such as waste incinerators and metals refining.

PCNs have been detected in several environmental matrices from Lake Ontario. PCNs were measured in air in Toronto, Canada and over Lake Ontario with the highest concentrations found in Toronto (Harner & Bidleman, 1997; Helm & Bidleman, 2003; Helm et al., 2003). The urban and industrial areas at the west end of Lake Ontario influence air concentrations with higher concentrations found in air collected over this part of the lake (Helm et al., 2003). The atmosphere may continue to be a source of PCNs to Lake Ontario but this needs further investigation. PCNs also biomagnify in the Lake Ontario foodweb with trophic magnification factors and predator-prey bioaccumulation factors similar to PCBs and p,p'-DDE (Helm et al., 2005). PCNs in Lake Ontario surface sediments were found to have concentrations considerably higher than found in background sites in Lake Michigan, but much lower than concentrations in highly contaminated portions of the Detroit River. Isomer patterns indicate that the source of PCNs in Lake Ontario sediments may differ from those in the Detroit River.

Recent actions:

- Environment Canada is currently conducting a screening level assessment under the *Canadian Environmental Protection Act, 1999*.

10.3.3 Other Emerging Chemicals

Other classes of emerging chemicals include endocrine disrupting compounds (EDCs), pharmaceuticals, and personal care products. EDCs refer to chemicals that may mimic hormones or interfere with hormone receptors in some manner, and include many pharmaceutical and personal care products. EDCs include birth control hormones, detergents such as nonylphenol ethoxylates, and plastics components such as bisphenol A. Pharmaceuticals which may be present in the aquatic environment include antibiotics, anti-depressants, lipid regulators, and analgesics/ anti-inflammatory drugs. Personal care products include fragrance compounds such as synthetic musks, anti-microbial agents like triclosan, detergents/ surfactants, and cosmetic agents. There have been recent reports detecting some of these compounds in surface waters, particularly in Areas of Concern such as Hamilton Harbour. It is unclear at this time whether these compounds are of significant concern in Lake Ontario.

Activities Regarding Emerging and Other Chemicals of Concern

LaMP agencies are supportive of projects assessing sources and occurrence of other chemicals of concern in Lake Ontario, including:

- collection and dating of Lake Ontario sediment cores from the Mississauga Basin and the Niagara Bar and subsequent analysis for a range of brominated flame retardants, perfluorinated compounds, polychlorinated naphthalenes, polychlorinated dioxins and furans, and dioxin-like PCBs. This project, funded in part through the Canada-Ontario Agreement (COA) involves Environment Canada, Ontario Ministry of the Environment, NYSDEC, and USEPA; and

- a joint project between the Ontario Ministry of the Environment, the Department of Fisheries and Oceans and Environment Canada assessing the occurrence and bioaccumulation of polychlorinated naphthalenes in Lake Ontario sediment and biota.

The LaMP will continue to encourage partner agencies to remain proactive in this area, reporting new findings to the LaMP as they become available.

10.3.4 Fish and Wildlife Disease

Fish and wildlife die-offs are common on Lake Ontario and are usually attributable to rapid changes in environmental conditions such as water temperature fluctuations and more rarely to events like spills, water draw downs, etc. However, occasional die-offs do occur that can either be attributed to new or emerging diseases affecting fish and wildlife, or to ongoing concerns. The first category of emerging issues for this section is ‘new’ diseases and the second category is ongoing issues about prevention of the spread of diseases.

New Diseases

In early spring 2005, a major die off of freshwater drum occurred in the Bay of Quinte in which thousands of drum died. Lab reports have since confirmed that Viral Haemorrhagic Septicemia (VHS) virus was associated with the drum mortalities. This virus has not previously been detected in the Great Lakes. The Ontario Ministry of Natural Resources notified the Department of Fisheries and Oceans (as required) and other stakeholders. As well, the Fish Health Committee of the Great Lakes Fishery Commission was notified. The Department of Fisheries and Oceans is doing further testing on drum to see if the strain can be better identified.

As an aside, muskellunge were found dead and floating in the St. Lawrence River primarily in the Thousand Islands area shortly after the drum die off. Pathologists in the state of New York suggest a bacterial infection brought on due to stress from water temperature and/or spawning were likely causes of the muskellunge die-off. As well, round goby were being found dead throughout eastern Lake Ontario during the spring die-off of both drum and muskie. No cause can be attributed to the die-off of goby. It is clear that botulism was not the cause. Samples of musky and goby are undergoing further testing.

The second recent or ‘new’ disease is a response to infection by a parasite called *Heterosporis* sp. This is a microsporidian found in crappie and yellow perch in Lake Ontario that forms spores inside muscle cells causing the flesh to appear opaque or freezer burnt, resulting in a decline in flesh quality and appearance, and a loss of marketability. How this parasite got into Lake Ontario is not known, as the only other sites where it is found are a number of inland waterbodies in Wisconsin, Minnesota and Michigan.

Like non-native fish species, there is a large list of diseases that could be introduced to Lake Ontario or may already be here. Fish diseases that are a potential concern for Lake Ontario are piscirickettsia, Koi herpes virus, largemouth bass virus, and spring viremia of carp; the latter of which has been detected in farmed koi in North Carolina and Virginia, and was diagnosed as the cause of a mass mortality of wild carp in Wisconsin.

Transmission Prevention

The Great Lakes Fish Health Committee, a body of the Great Lakes Fishery Commission, is focusing a lot of effort at identifying and reducing the modes of transmission of fish diseases and movement of organisms causing disease states in fish within the Great Lakes and connected inland waterbodies. Modes of transmission being reviewed are purposeful introductions, baitfish use, contiguous waterways, and by birds.

The LaMP supports the initiatives of the Great Lakes Fishery Commission to monitor and address the outbreaks and transfer of fish diseases in the Great Lakes basin.

10.3.5 Type E Botulism

Recent outbreaks of Type E Botulism in Lake Ontario waterbirds has raised the concern of US and Canadian conservation and natural resource agencies who are keeping a close watch for potentially affected fish and waterbirds along the shorelines of the lake.

Type E Botulism is a specific, ubiquitous strain of the botulinum bacterium most commonly affecting fish-eating birds. It causes rapid paralysis in the affected birds and often is fatal. The bacterium, *Clostridium botulinum*, produces the Type E Botulinum toxin. Spores of the bacteria occur naturally within the water and sediment of the Great Lakes. The spores are harmless, but under specific conditions of appropriate temperatures, anoxia (no oxygen) and rich organic medium, these spores vegetate and grow to produce the toxin.

Type E Botulism is of particular concern to the Lake Ontario LaMP, because it affects healthy populations of gulls, bald eagles and lake trout -- key ecosystem indicators. During the summer and autumn of 2002, at least five dead gulls and four ducks found along New York’s eastern Lake Ontario shoreline were confirmed to have died from the Type E Botulinum toxin. It was unknown whether the birds had consumed the toxin in Lake Ontario or elsewhere. In the Niagara region of Lake Ontario, botulism has been linked to the death of small numbers of fish and birds since 2002. In 2004, Type E Botulism was allegedly responsible for several long-lasting and large die-offs of birds (and possibly fish) in the north east part of the lake. This outbreak was first reported on August 9, 2004, and reports continued into November of the same year. During late July and early August 2005, moderate numbers of dead and dying waterfowl and fish showing the signs of Type E Botulinum poisoning were observed in Lake Ontario. Testing by the Canadian Cooperative Wildlife Health Centre (University of Guelph) confirmed Type E Botulism in a double-crested cormorant collected on the south shore of Prince Edward County, Ontario. The New York State Department of Environmental Conservation confirmed that several birds of different species collected from the eastern Lake Ontario, Cape Vincent and Galloo Island area, in August of 2005, also died from Type E Botulinum toxin.

There is a loose association between birds affected by botulism, and a diet which includes a high proportion of zebra or quagga mussels and round gobies (both recent invaders of the Great Lakes). Although the linkage from lower food web to top predators is not well understood, it has been suggested that the digestive waste of zebra and quagga mussels, as well as the redox conditions in these mussels, may provide suitable habitat for the bacteria to proliferate and produce toxin. Fish that eat these mussels, or other food items found among the mussels, may consume the pre-formed toxin and pass it on to fish-eating birds. Research to determine if this is indeed the case is currently underway in the Aquaculture Centre, University of Guelph, Ontario.

Type E botulinum toxin can be harmful or even fatal to humans and other animals if they consume birds or fish that contain the pre-formed toxin. There have been no reports of any human illnesses associated with the outbreaks in Lake Ontario or Lake Erie. Type E Botulism is destroyed by heat through the proper cooking of fish and game birds. People are advised not to handle dead or dying animals they suspect to have botulism or that are situated in areas having a history of botulism outbreaks.

In response to the Type E botulism outbreaks, which have also been occurring in Lakes Erie and Huron since 1999, the US Environmental Protection Agency and Environment Canada have supported research projects to help understand the sources, conditions of production, exposure pathways, and possible predictive indicators of the toxin.

Any discovery of dead or dying waterbirds, or fish, showing clinical signs of botulism such as an inability to walk, fly or swim, should be reported to the New York State Department of Environmental Conservation, or the Ontario Ministry of Natural Resources immediately. For information on local offices see your phone book or check the website – in the United States at www.dec.state.ny.us/ or in Canada at www.mnr.gov.on.ca/MNR/.

10.3.6 Climate Change

Appropriate text for this section will be inserted in a future Lake Ontario LaMP Status Report.

10.3.7 Harmful Algal Blooms

Microcystis, Anabaena, Planktothrix, Oscillatoria are naturally occurring algae which produce cyanotoxins including microcystins (MCs), the most common form (Falconer 1995; Codd et al. 2005). Conditions of high temperature, high nutrients and low circulation can produce conditions that allow these algae to rapidly grow producing noxious algal blooms on the water's surface which can result in elevated MC levels. In addition to serious aesthetic problems, elevated MC levels raise potential health concerns for organisms that may come in contact with the blooms and may impact the structure of the food web where the blooms occur (Carmichael 1997). Generally these problems are restricted to bays and marshes. The blooms persist until wind, wave or precipitation events break up the surface layer of algal blooms. Currents, waves and lower nutrient levels of Lake Ontario's nearshore and open waters do not favor the development of MC-related algal blooms.

Health Canada has developed a drinking water guideline of 1.5 ug/L for microcystin-LR, one of the most toxic and also one of the most common microcystin congeners forms found in the Great Lakes (e.g. Brittain 2001). As most major drinking water intakes are located away from shore in fairly deep, well mixed waters, microcystin is not expected to present a problem for public drinking water supplies although it may be a potential concern for private water sources with intakes in shallow waters with poor water circulation. Researchers sampling blooms in restricted bays, which could be considered representative of a worst case scenario, have found MC levels well below the Health Canada guideline.

Ontario has adopted the Health Canada guideline as the maximum acceptable concentration (MAC). Ontario advocates visual monitoring of drinking and recreational water bodies with a history of algal blooms during the summer when the risk for bloom formation and MC production is greatest according to a protocol similar to that developed in Europe and Australia (OME 2003).

Some research suggests that the incidence of microcystin related planktonic blooms in Lake Ontario embayments and the St. Lawrence River is increasing in some north shore areas (Watson et al. 2003; Watson and Millard 2002, 2003; Boyer et al.; Watson and Ridal unpublished). Dreissenid mussels and increasing urban development and associated diffuse shoreline nutrient influx have been implicated as potential factors promoting these blooms (e.g. Abiley et al. 1999; Nicholls 2001; Vanderploeg et al. 2001, Baker et al.).

10.4 Actions and Progress

The information contained in this chapter has been compiled based on documents produced up to October 2005. The table below contains a summary of the actions and progress on significant ongoing and emerging issues within Lake Ontario. The LaMP process is a dynamic one and therefore the status will change as progress is made. For many of the emerging issues, the LaMP partners are sharing information so the LaMP as a whole can maintain its awareness of the status of the various issues. As new information becomes available the LaMP will assess whether there is a need for a coordinated binational action plan.

This chapter will be updated in future LaMP reports as appropriate.

Table 10.2 Summary of Actions and Progress

ISSUE	ACTIONS AND PROGRESS
Protection and Restoration of Native Species	• **Lake Trout** o US Fish and Wildlife Service and Canadian Department of Fisheries and Oceans have controlled Sea Lamprey at or near levels targeted by the Lake Ontario Committee of the Great Lakes Fishery Commission. • **American Eel** o US and Canada are taking steps to provide additional protection and aid in the rehabilitation of this species. o The commercial fishery for American Eel has been closed in Ontario (no commercial fishery existed within the US portion of Lake Ontario and the St. Lawrence River). o Both US and Canada are supporting research directed at improving the ability to manage American Eel.
Invasive Species	• **Regulatory Initiatives** o US Coast Guard voluntary actions to manage ballast water under the National Invasive Species Act (1996) became mandatory on July 28, 2004. o Transport Canada's proposed *Ballast Water Control Management Regulations* under the Canada Shipping Act have undergone public comment. The Regulations are expected to come into force in 2006. o US Coast Guard and Transport Canada are jointly working on measures to manage ships with no ballast on board. o Ontario recently passed legislation prohibiting the possession and sale of live individuals of the four Asian carp species, snakeheads and the round and tubenose goby. o New York State has banned the possession of three live species of Asian carp (Bighead, Silver and Black) and all species of live snakeheads, and their eggs, with an exemption for allowing live bighead carp for retail sale purposes in limited sections of New York City. Bighead carp must be killed at the time of sale to prevent further transport and distribution within the state. • **Education and Outreach** o The LaMP agencies, other governmental agencies and NGOs are all involved in coordination and promotion of various education and outreach activities. • **Other Initiatives** o National initiatives are underway in US and Canada aimed at prevention, early detection, and rapid response. o US Fish and Wildlife Service surveys the Lower Genesee River twice a year as part of an early detection program for the potential introduction of ruffe to Lake Ontario.

Table 10.2 Summary of Actions and Progress

ISSUE	ACTIONS AND PROGRESS
Type E Botulism	• **Research** o US Environmental Protection Agency, Environment Canada have supported research projects to help understand the sources, conditions of production, exposure pathways, and possible predictive indicators of the Type E Botulinum toxin. • **Monitoring and Tracking** o New York State Department of Environmental Conservation, Ontario Ministry of Natural Resources, Environment Canada and other partners continue to monitor and track the occurrence of Type E Botulism within Lake Ontario.
Lake Ontario Water Levels	• Lake Ontario LaMP has been participating in the IJC Water Level study and communicated the LaMP support for "Environmentally Balanced" Plan B to the IJC Water Levels Study Team.
Emerging Chemicals of Concern	• **Voluntary Actions** o The Great Lakes Chemical Corporation agreed to voluntarily phase-out PBDE (penta- and octa-BDE products) production by December 31, 2004 o May 2000 3M voluntarily stopped the production and use of PFOS (e.g. in Scotchgard™) • **Regulatory Initiatives** o May 2004, PBDEs were defined as "toxic" under the *Canadian Environmental Protection Act*. This assessment relied, in part, on data generated through the LaMP for Lake Ontario surface water concentrations. o October 2004 draft Screening Assessment on Perfluorooctane Sulfonate, Its Salts and Its Precursors, proposes that PFOS, its salts and its precursors be considered "toxic" under the *Canadian Environmental Protection Act*. o Environment Canada is currently conducting a screening level assessment for Polychlorinated naphthalenes (PCNs) under the *Canadian Environmental Protection Act*. o August 2004: The manufacture, process or distribution of brominated flame retardants were prohibited within the New York State under Section 37-0111 of the New York State Laws. • **Monitoring and Trend Analysis** o Joint U.S., Canadian project to collect, date and analyze Lake Ontario sediment cores from the Mississauga Basin and the Niagara Bar. o Joint Canadian Agency project to assess the occurrence and bioaccumulation of polychlorinated naphthalenes in Lake Ontario sediment and biota. o US EPA – routine monitoring of flame retardants (PBDEs, PCNs and PFOS) under the Great Lakes Fish Monitoring Program (GLNPO). • **Other Actions** o January 2005 the US EPA draft Risk Assessment of the Potential Human Health Effects Associated with Exposure to Perfluorooctanoic acid and its salts (PFOA). o December 2004, US EPA issued a draft "Significant New Use Rule" under the Toxic Substances Control Act for two of the three major commercial PBDE products.

Table 10.2 Summary of Actions and Progress

ISSUE	ACTIONS AND PROGRESS
Fish and Wildlife Diseases	• **Prevention** o LaMP partner agencies are working with the Great Lakes Fishery Commission to identify and reduce the modes of transmission of fish diseases and movement of organisms causing disease states in fish within the Great Lakes and connected inland waterbodies.
Rapid Urbanization of Western Lake Ontario	• **Regulatory Initiatives** • The Province of Ontario has introduced the Greenbelt Act, 2005 which enables the creation of a Greenbelt Plan to protect approximately 1.8 million acres of environmentally sensitive and agricultural land in the Golden Horseshoe (western Lake Ontario)
Harmful Algal Blooms	• Health Canada has developed a drinking water guideline of 1.5ug/L for microcystin-LR. • Ontario has in place a monitoring procedure for high risk areas and a protocol that is implemented in the event of a potential threat (i.e. algal bloom) to protect drinking water. **Research** • Environment Canada is conducting and supporting research on occurrence and causes of these recent blooms.

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