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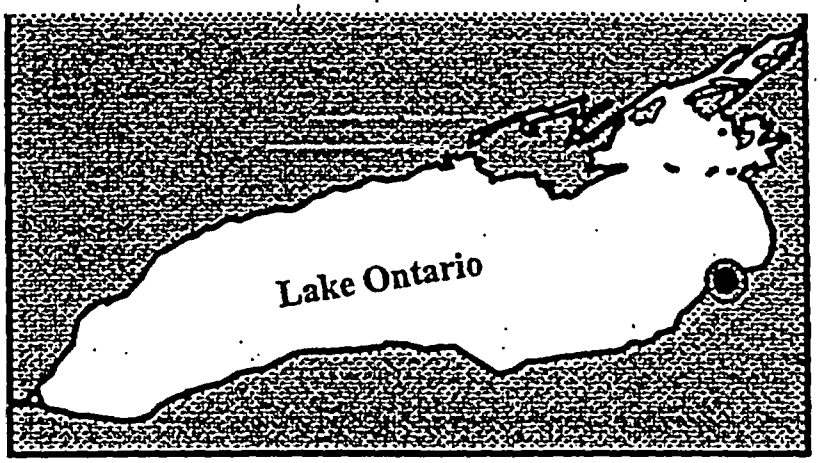
Nine Mile Point Nuclear Station Unit 1 1997, April 1998

Niagara Mohawk Power Corporation



April 1998

FINAL

Entrainment Abundance Report

Nine Mile Point Nuclear Station

Unit 1

1997

EA Engineering, Science, and Technology

EA Engineering, Science, and Technology. Entrainment Monitoring at Nine Mile Point Unit 1, 1997. Prepared for Niagara Mohawk Power Corporation. April 1998.

Nine Mile Point 1997 entrainment

1. INTRODUCTION

The Nine Mile Point Nuclear Station Unit 1 (NMP Unit 1) is solely owned and operated by Niagara Mohawk Power Corporation (Niagara Mohawk). The station is located on a 900-acre site in Oswego County, New York, and is approximately 6.8 mi north-northeast of the City of Oswego. The power conversion system utilizes a 1,850-megawatt (thermal) boiling water reactor designed and manufactured by the General Electric Corporation, and a 610,000-kilowatt (net electric) turbine-generator.

NMP Unit 1 has been operational since December 1969. The station is a critical, integral part of the New York State Energy Master Plan, and a cost efficient source of electrical energy within Niagara Mohawk's service area.

NMP Unit 1 utilizes a once-through, non-contact cooling water system to dissipate thermal energy from the main condensers and auxiliary cooling systems. Cooling water is drawn from Lake Ontario by means of two main circulating water pumps rated at 946.25 m^3 (250,000 gal) per minute (total) and two service water pumps which operate at approximately 68.13 m^3 (18,000 gal) per minute (total). Throughout most of the year, only one of the service water pumps typically operates; both service water pumps may operate during the mid-summer months.

The cooling water intake structure is an open-sided hexagonal concrete structure located in approximately 5.5 m (18 ft) of water (mean lake level) and approximately 259 m (850 ft) offshore from the existing lake shoreline. The cooling water discharge structure is of a design that is similar to the intake structure. This structure is hexagonal with open-sided ports and is located approximately 102 m (335 ft) from the shoreline and 3.8 m (12.5 ft) below the mean lake water surface.

Aquatic organisms, detritus, and other debris enter the intake tunnel with the water pumped from Lake Ontario in the vicinity of the submerged intake structure. Trash racks remove large items, such as logs; other material is entrapped on the three traveling intake screens comprised of 9-mm (3/8-in.) mesh (impingement) or, if small enough, pass through the traveling screens and is entrained into the non-contact cooling water system. Periodically, the traveling screens are rotated and washed to remove any accumulation of impinged organisms or other material into a sluiceway which empties into an impingement collection basket. The aquatic organisms impinged at NMP Unit 1 have been monitored since 1972 in order to estimate species abundance and composition. During 1997, EA Engineering, Science, and Technology monitored the abundance of entrained organisms in samples collected from the NMP Unit 1 discharge canal. Entrainment samples were collected during daylight and nighttime one day per week from April through August 1997 (a total of 88 samples).

This report presents the results of the entrainment monitoring program conducted by EA during 1997, as required by the State Pollutant Discharge Elimination System (SPDES) Permit No. NY 0001015, Section III.2 (dated 1 December 1994), covering NMP Unit 1.

Entrainment sampling at NMP Unit 1 in 1997 resulted in the collection and identification of 9 fish taxa. Alewife was the most abundant species (2,938) comprising 96 percent of the total fish catch (3,069). Alewife, threespine stickleback, and tessellated darter combined (3,041) accounted for 99 percent of all fish collected.

2. METHODS

2.1 FIELD SAMPLING

To provide seasonal distribution information, entrainment abundance samples were collected each week from April through August 1997. Sampling on each date was conducted during two discrete segments (daylight and nighttime) to provide information on diel patterns of abundance. During each segment, 2 consecutive samples (4 per sample day) of approximately 100 m^3 each were collected. A total of 88 entrainment abundance samples were processed for ichthyoplankton. Sample dates, number of samples, and volumes filtered are listed in Table 1.

2.1.1 General Characteristics of the Pump and Net/Barrel Sampler

2.1.1.1 Sampler Location

Samples at NMP Unit 1 were collected from the discharge canal at the screenhouse building. The inlet of the sampler's 4-in. intake pipe was situated at approximately mid-depth in the center of the discharge tunnel at an access point in the floor south of the tempering gates. Sampling at the discharge canal improves the accuracy of entrainment abundance estimates since the potential sampling bias introduced at the intake by temporal and spatial patchiness of organisms is minimized at the discharge as a result of mixing during passage through the cooling water system.

2.1.1.2 Pump Specifications

The pump and net/barrel abundance sampler included a 3-in. electric trash pump fitted with 4-in. suction and discharge hose to direct the sampled water to the collection device. The length of the hose from the discharge tunnel to the sampling pump was 25 ft. The length of hose from the pump to the collection device was 10 ft.

2.1.1.3 Net/Barrel Specifications

The pump and net/barrel system used is depicted on Figure 1. A 3-in. (7.6-cm) electric trash pump (Marlow Model No. 3CR18EC) fitted with a 4-in. suction and discharge hose was used to direct the sample through an in-line Signet electronic flowmeter which measured flow rate and accumulated total volume. Two 4-in. PVC ball valves allowed the operator to divert flow into one of two net/barrel systems so that sample collection and net washdown/sample recovery could occur simultaneously without interruption in sampling flow or loss of material. Each tank (3.3 ft [1 m] in diameter and 3.9 ft [1.2 m] in height) contained a 2-ft (0.61-m) diameter (Table 2) cylindrical collection net made of 333-μ mesh with a submerged area of approximately 10.33 ft^2 (0.96 m^2) (Figure 1). Average flow velocity through the collection net was 238 gal/minute (900 L/minute). The bottom of the net was attached to a polyethylene funnel to simplify transfer of the sample to a container.

2.2 FIELD COLLECTION PROCEDURES

This section summarizes the field sampling procedures for collection of entrained ichthyoplankton at NMP Unit 1 which are detailed in the Field Standard Operating Procedures, Entrainment Monitoring Program at Nine Mile Point Generating Station Unit 1 (EA 1997)[1].

Prior to initiating collection of the first sample for each sampling event, the sampling pump was primed and the flow was adjusted to a rate of approximately 900 L/minute, with a range of 800-1,000 L/minute. To measure the cumulative sample volume, the exact time and total volume from the flowmeter readout were recorded at the beginning and end of each sample. After the sample flow was discontinued, the barrel was drained and the interior of the net was thoroughly rinsed into a codend with filtered water. All detritus and organisms were preserved in labeled jars with formalin and stained with rose bengal to facilitate later removal of organisms from the sample. In order to minimize clogging and prevent loss of sample, the sample flow was switched between barrels at 1-hour intervals. The target sample volume was 100 m^3 during each of the 4 samples.

Water temperature and plant operating conditions were recorded for each sampling period.

2.3 LABORATORY PROCEDURES

Entrainment samples were processed using the following procedures. Fish eggs, larvae, and juveniles were removed from the samples as follows:

- Samples were poured through a 333-µm mesh sieve and rinsed with water to remove the preservative.
- The sample contents were carefully washed from the sieve into a pan and examined under a magnifying lens. Samples which contained large numbers of eggs or larvae were subsampled in accordance with the Standard Operating Procedure.
- Fish eggs, larvae, and juveniles were removed from the sample or subsample and placed in a vial containing alcohol preservative.
- When sorting was completed, the sample was rechecked for missed organisms by a second person as quality control on the sorting procedure. The count of eggs and "larvae" (i.e., yolk-sac larvae, post yolk-sac larvae, and juveniles) removed from each sample, along with the date and time sorting was completed, were recorded in the sorting log.

1. EA Engineering, Science, and Technology. 1997. Field Standard Operating Procedures, Entrainment Monitoring Program at Nine Mile Point Generating Station Unit 1. March.

The life stage of each specimen was determined based on the following morphometric characteristics:

Egg—The embryonic developmental stage, from spawning until hatching. Eggs frequently become damaged during collection and sample processing. Damaged eggs are counted only if an embryo can be matched to an egg capsule (chorion).

Yolk-sac Larva—The transition stage from hatching through the development of a complete, functional digestive system (regardless of the degree of yolk and/or oil globule retention).

Post Yolk-sac Larva—The transition stage from development of a complete, functional digestive system to transformation to juvenile form (regardless of the degree of yolk and/or oil globule retention), including the leptocephalus stage of eels.

Juvenile—The stage from completed transformation to Age 1; juveniles have a full complement of fin rays identical to that of an adult.

Characteristics considered in species determinations included the following:

- Morphology (overall shape, relative size, and position of various body parts and structures).
- Presence of specialized structures (e.g., oil droplets).
- Meristics (counts of myomeres, fin rays).
- Pigmentation (presence or absence of melanophores in specific positions).
- Rate of development (size when certain characteristics are acquired or lost).
- Relative time of spawning season versus time of capture.
- Geographic range.

Higher taxonomic categories (e.g., genus, family) were used only when a specimen was damaged, or belonged to a group or stage which has not been adequately described to make a conclusive assignment to a species.

2.4 ESTIMATION OF NUMBERS ENTRAINED

The primary sources of ecosystem effects from cooling water withdrawal at steam electric generating stations are entrainment (the passage of small organisms through the cooling water system with cooling water) and impingement (the entrapment of organisms against the screens at the cooling water intake). Estimates of total numbers entrained have been calculated by scaling up the entrainment sample densities (number of entrained organisms collected/m^3 of cooling water sampled) based on the total plant cooling water flow represented by the sampling period. This calculation is made using the following formula:

$$N_{st} = D_{st} \times F_t$$

where

N_{st} = Estimated number of organisms of species/life stage (s) entrained during time interval (t).
D_{st} = Density of species/life stage (s) during time interval (t).
F_t = Total NMP Unit 1 cooling water flow during interval (t).

Density (D_{st}) is determined from the entrainment samples as follows:

$$D_{st} = n_{st} \times v$$

where

n_{st} = Number of organisms of species/life stage (s) collected in samples from the time period (t).
v = Volume of the entrainment monitoring samples from the period (t).

Samples collected on a given sampling date were considered to be representative of densities over the period extending between the midpoint of the interval from the previous date to the midpoint of the interval to the subsequent sampling date. The total NMP Unit 1 cooling water flow is the sum of the daily flows observed during the period represented by the weekly sampling effort.

3. ABUNDANCE AND PATTERNS OF ENTRAINMENT

During the process of withdrawing water for cooling purposes at a facility like NMP Unit 1, small organisms in the source waterbody are carried through the station along with the cooling water. This process is known as pumped entrainment. Typically, entrained organisms are small, weakly-swimming organisms or younger life stages of more mobile organisms which are planktonic or semi-planktonic and can be carried along with the cooling water flow. During passage through the cooling water system, entrained organisms can be subject to mechanical, thermal, and chemical stresses. Their ability to withstand these stresses varies widely among taxa and facility design. The purposes of this section are to present the entrainment data collected during the NMP Unit 1 studies, to estimate the rates (densities) at which selected taxa were entrained during the course of the study, and to estimate annual entrainment losses at NMP Unit 1. These estimates do not account for survival of entrained organisms which may occur, the high rates of natural mortality experienced by these early life stages, and the effect of biological compensation related to effects of entrainment on aquatic populations.

3.1 OVERALL ENTRAINMENT SPECIES COMPOSITION

A total of 9 distinct taxonomic groups of fish (Table 3), comprising a total of 3,069 individual organisms, were collected during entrainment sampling at NMP Unit 1 (Table 4). Seven of these groups were identified to species whereas the remaining two represent family groupings. Sampling was performed one day (24 hours) per week during the principal entrainment period, April-August 1997. This period encompassed the annual entrainment season for most taxa inhabiting eastern Lake Ontario. With respect to life stage, post yolk-sac larvae were most commonly collected (40 percent); with the next most abundant life stage being eggs (35 percent) and yolk-sac larvae (24 percent). Only a relatively small number of juveniles (1 percent) were collected. Less 0.1 percent of the total catch was damaged or otherwise unidentifiable to taxonomic grouping.

3.2 ENTRAINMENT PATTERNS FOR MOST ABUNDANT TAXA

The most abundant taxon in the entrainment collections was alewife (Table 4). This single species accounted for almost 96 percent of the organisms collected in entrainment sampling at NMP Unit 1; 2,938 were collected from June through the end of sampling in August (Figure 2). More than 35 percent of the alewife collected were eggs; most of the remaining were yolk-sac larvae and post yolk-sac larvae (24 and 40 percent, respectively). Only a few juveniles were collected (<1 percent). Peak abundance of eggs through post yolk-sac larvae (approximately 75 percent) occurred during July 1997. Juveniles were most abundant in August 1997. Eggs and post yolk-sac larvae were more abundant in night samples than daylight samples (Figure 3, Table 5). The strong nocturnal distribution of eggs may reflect spawning in shallower waters during adult movement inshore at night. Yolk-sac abundance was similar among day and night samples. Alewife were most abundant between 2 and 6 mm (approximately 60 percent), but ranged up to 36 mm (Figure 4, Table 6).

Tessellated darter was the next most abundant taxa collected in entrainment samples (2 percent). They were collected primarily as yolk-sac (32 percent) and post yolk-sac larvae (54 percent) during June and July 1997 (Figure 5). Only six eggs were collected which is consistent with the adhesive nature of the eggs and the spawning habits of this species. Yolk-sac and post yolk-sac larvae exhibited a nocturnal distribution which appeared to become stronger with age (Figure 6). Tessellated darters were entrained between 2 and 12 mm, but were most abundant (approximately 90 percent) between 4 and 8 mm (Figure 4).

Threespine stickleback, the next most abundant species (only 1 percent of the total catch), was collected almost exclusively as eggs during April-June 1997 (Table 4). The remaining 28 entrained organisms were distributed among 6 taxa and accounted for less than 1 percent of the total collection.

3.3 ESTIMATES OF TOTAL ANNUAL ENTRAINMENT LOSS FOR SELECTED TAXA

Densities of entrained ichthyoplankton during the 1997 monitoring program at NMP Unit 1 calculated from organism counts in samples and sample volumes are presented in Table 7. Estimates of the total numbers entrained were extrapolated from these sample densities, scaled up using the cooling water volumes recorded during the 1997 monitoring program (Table 8). The SPDES Permit (NY000 1015) for NMP identifies species of concern (Additional Requirement III.3.b) including white perch, smallmouth bass, yellow perch, alewife, rainbow smelt, white bass, and all members of the family Salmonidae. Of these taxa, no white perch, white bass, smallmouth bass, or salmonids were collected during the 1997 entrainment monitoring studies.

Based on the total cooling water flow pumped between April and August 1997, it is estimated that 86,756,458 ichthyoplankters were entrained at NMP Unit 1, of which eggs, yolk-sac, and post yolk-sac larvae accounted for 35, 23, and 40 percent, respectively. Alewife entrainment was estimated at 78,688,029 (91 percent), with tessellated darter and threespine stickleback accounting for another 4 and 3 percent of entrainment, respectively. Only six yellow perch (2 yolk-sac larvae and 4 post yolk-sac larvae) were collected which extrapolates to a total of 286,373 yellow perch entrained from April to August 1997. Only two rainbow smelt (1 egg and 1 juvenile) were collected which extrapolates to a total of 111,622 smelt entrained from April to August 1997. These estimated numbers entrained do not account for survival by some organisms of the entrainment process, the relatively high natural mortality rates experienced by these early life stages, and the influence of biological compensation on the impact of entrainment on aquatic populations and communities.

TABLE 1 SUMMARY OF SAMPLE DATES, SAMPLE VOLUMES, AND COOLING WATER FLOW RATES DURING THE ENTRAINMENT MONITORING PROGRAM AT NINE MILE POINT NUCLEAR STATION UNIT 1, 1997

Month	Dates Sampled	Entrainment Sample Volume (m^3/sample)			Plant Cooling Water Volumes (m^3×1,000/day)			Standard Deviation
		Minimum	Maximum	Mean	Minimum	Maximum	Mean	
APR	2, 3, 9, 16, 23, 30	100	100	100	46.6	69.8	56.1	7.5
MAY	7, 14, 21, 28	100	100	100	51.8	1,452.1	1,002.3	541.4
JUN	4, 11, 18, 19, 25	100	100	100	1,445.3	1,521.6	1,464.4	24.0
JUL	2, 9, 16, 23, 30	100	100	100	1,503.4	1,546.4	1,524.5	15.9
AUG	6, 13, 20, 27, 28	100	100	100	1,518.1	1,545.6	1,540.9	7.9

TABLE 2 SPECIFICATIONS OF PUMP/NET BARREL SAMPLER

Parameter	Specification
Net dimensions	0.61-m diameter × 0.5-m height
Net mesh	500-μ nylon mesh
Filtration Area	0.958 m^2
% open area	49
Amount of open area	0.47 m^2
Velocity at sample inlet	1.85 m/second (at 900 liter/min)
Filtration rate	0.8-1.2 m^3/minute
Average through-net velocity	0.032 m/second
Average sample volume	250 m^3 (four 60-minute subsamples)

TABLE 3 LIST OF COMMON AND SCIENTIFIC NAMES OF ICHTHYOPLANKTON TAXA ENTRAINED AT NINE MILE POINT NUCLEAR STATION UNIT 1 DURING 1997 MONITORING PROGRAM

Common Name	Scientific Name
Alewife	*Alosa pseudoharengus*
Carp	*Cyprinus carpio*
Minnow family	Cyprinidae
Rainbow smelt	*Osmerus mordax*
Threespine stickleback	*Gasterosteus aculeatus*
Sunfish family	Centrarchidae
Tesselated darter	*Etheostoma olmstedi*
Yellow perch	*Perca flavescens*
Mottled sculpin	*Cottus bairdi*

TABLE 4. TOTAL NUMBER OF ORGANISMS BY LIFE STAGE/TAXON COLLECTED DURING ENTRAINMENT MONITORING PROGRAM AT NINE MILE POINT NUCLEAR STATION UNIT 1, APRIL-AUGUST 1997

Life Stage	Taxon	April	May	June	July	August	Total
Eggs	Alewife			19	938	72	1,029
	Carp		2				2
	Minnow family			1	1		2
	Rainbow smelt	1					1
	Sunfish family		2	1			3
	Tessellated darter			6			6
	Threespine stickleback	2	9	26			37
Subtotal		3	13	53	939	72	1,080
Yolk-Sac Larvae	Alewife				492	206	698
	Minnow family			1	1		2
	Tessellated darter			5	16		21
	Yellow perch		2				2
Subtotal		0	2	6	509	206	723
Post Yolk-Sac Larvae	Alewife		1	9	757	416	1,183
	Minnow family			1	1		2
	Mottled sculpin			7			7
	Tessellated darter		3	7	25		35
	Threespine stickleback					1	1
	Unidentifiable				1		1
	Yellow perch		4				4
Subtotal		0	8	24	784	417	1,233
Juveniles	Alewife				3	25	28
	Mottled sculpin			1			1
	Rainbow smelt					1	1
Subtotal		0	0	1	3	26	30
Unidentified	Tessellated darter				3		3
TOTAL		3	23	84	2,238	721	3,069

TABLE 5 SUMMARY OF ICHTHYOPLANKTON ENTRAINED BY DIEL TIME INTERVAL DURING MONITORING PROGRAM AT NINE MILE POINT NUCLEAR STATION UNIT 1, 1997

Life Stage	Taxon	Time Interval 0700-1859	Time Interval 1900-0659
Eggs	Alewife	106	923
	Carp		2
	Minnow family		2
	Rainbow smelt	1	
	Sunfish family	2	1
	Tessellated darter	6	
	Threespine stickleback	33	4
Yolk-Sac Larvae	Alewife	347	351
	Minnow family		2
	Tessellated darter	5	16
	Yellow perch	1	1
Post Yolk-Sac Larvae	Alewife	462	721
	Minnow family	1	1
	Mottled sculpin	6	1
	Tessellated darter	4	31
	Threespine stickleback		1
	Unidentifiable	1	
	Yellow perch	2	2
Juveniles	Alewife	7	21
	Mottled sculpin	1	
	Rainbow smelt		1
Unidentified	Tessellated darter		3

TABLE 6 LARVAL AND JUVENILE LENGTH DISTRIBUTION OF TAXA ENTRAINED DURING 1997 MONITORING PROGRAM AT NINE MILE POINT NUCLEAR STATION UNIT 1

Species	0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-17.9	18.0-19.9	20.0-21.9	22.0-23.9	24.0-25.9	26.0-27.9	34.0-35.9	Total
Alewife		206	214	80	47	42	19	16	11	12	5	4	4	3		663
Minnow family			1	3												4
Mottled sculpin				2	5	1										8
Rainbow smelt															1	1
Tessellated darter		2	20	32	1	1										56
Threespine stickleback				1												1
Yellow perch			3		1											4

TABLE 7 MONTHLY AVERAGE DENSITY (NUMBER/1,000 m^3) BY LIFE STAGE/TAXON IN SAMPLES COLLECTED DURING ENTRAINMENT MONITORING PROGRAM AT NINE MILE POINT NUCLEAR STATION UNIT 1, 1997

Life Stage	Taxon	Density (Number per 1,000m^3)				
		April	May	June	July	August
Eggs	Alewife			47.5	469.0	45.0
	Carp		20.0			
	Minnow family			5.0	3.3	
	Rainbow smelt	10.0				
	Sunfish family		10.0	10.0		
	Tessellated darter			12.0		
	Threespine stickleback	20.0	45.0	86.7		
Yolk-Sac Larvae	Alewife				246.0	128.8
	Minnow family			5.0	3.3	
	Tessellated darter			10.0	40.0	
	Yellow perch		6.7			
Post Yolk-Sac Larvae	Alewife		10.0	22.5	378.5	260.0
	Minnow family			5.0	3.3	
	Mottled sculpin			23.3		
	Tessellated darter		15.0	14.0	62.5	
	Threespine stickleback					10.0
	Unidentifiable				10.0	
	Yellow perch		13.3			
Juveniles	Alewife				1.5	15.6
	Mottled sculpin			3.3		
	Rainbow smelt					10.0
Unidentified	Tessellated darter				7.5	

TABLE 8 ESTIMATED TOTAL NUMBER AND PERCENT BY SPECIES OF ORGANISMS ENTRAINED BASED ON COOLING WATER FLOW RATES RECORDED DURING ENTRAINMENT MONITORING PROGRAM AT NINE MILE POINT NUCLEAR STATION UNIT 1, APRIL-AUGUST 1997

	Eggs		Yolk-Sac Larvae		Post Yolk-Sac larvae		Juveniles		Unidentified		Total	
Taxon	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Alewife	27,364,227	34.8	18,630,207	23.7	31,939,794	40.6	753,701	1.0			78,688,029	90.7
Carp	201,812	100.0									201,912	0.2
Minnow family	208,991	33.3	206,723	32.9	212,290	33.8					628,105	0.7
Rainbow smelt	3,922	3.5					107,600	96.4			111,622	0.1
Sunfish family	239,803	100.0									239,903	0.3
Tessellated darter	202,897	5.6	1,224,501	33.7	2,050,431	56.4			157,913	4.3	3,635,837	4.2
Threespine stickleback	2,283,189	95.5			108,150	4.5					2,391,440	2.8
Yellow perch			100,906	35.2	185,366	64.7					286,373	0.3
Mottled sculpin					416,215	88.8	52,445	11.2			468,759	0.5
Unidentifiable					105,275	99.9					105,375	0.1
TOTAL	30,504,841	35.2	20,162,337	23.2	35,017,522	40.4	913,746	1.1	157,913	0.2	86,756,458	100