HRBMP
Hudson River Biological Monitoring Program

Description of the Long River Ichthyoplankton Survey: A Component of the Historical Hudson River Biological Monitoring Program

1. The Long River Survey

1.1 Survey Design and Implementation

The Hudson River Biological Monitoring Program (HRBMP) is a large-scale comprehensive long-term survey program covering the Hudson River Estuary (HRE) from Battery Park (river mile [RM] 0) to Albany (RM 152), NY. The initial purpose of the HRBMP was to quantify HRE fish distribution, relative and absolute abundances, and species population and community health, to understand the potential effects of Indian Point and other power generation facilities and anthropogenic activities. The historical HRBMP, gifted to and curated by the Chen Lab at Stony Brook University, includes the six core surveys conducted from 1974 through 2017. The three major river-wide fish surveys (Long River Ichthyoplankton Survey [LRS], Fall Juvenile Survey [FJS], and Beach Seine Survey [BSS]) follow random stratified survey designs consistently over their survey period. Although the overall survey design is relatively stable, all the survey programs in the historical HRBMP experienced large and frequent changes in survey protocols to address emerging issues and logistic limitations over the multi-decadal survey period. The HRBMP programs collect some data on older fish, but mainly target the early life history stages from eggs to young-of-year (YOY). From 1974 through 2017, the LRS collected data on more than 160 species in the HRE with more than 100,000 tow samples. The initial key fish species targeted by the HRBMP were, Atlantic Tomcod (*Microgadus tomcod*), Striped Bass (*Morone saxatilis*), and White Perch (*M. americana*). However, additional species of interest were added over the duration of the survey (Table 1).

Table 1. Species of interest over the duration of the LRS.

Year(s)	Species of Interest
1974	Striped Bass
1975-1981	Atlantic Tomcod, Striped Bass, White Perch,
1982-1989	Alewife, American Shad, Atlantic Sturgeon, Atlantic Tomcod, Bay Anchovy, Blueback Herring, Shortnose Sturgeon, Spottail Shiner, Striped Bass, Weakfish, White Catfish, and White Perch
1990-1991	Alewife, American Shad, Atlantic Sturgeon, Atlantic Tomcod, Bay Anchovy, Blueback Herring, Rainbow Smelt, Shortnose Sturgeon, Spottail Shiner, Striped Bass, Weakfish, White Catfish, and White Perch
1992-1996	Alewife, American Shad, Atlantic Sturgeon, Atlantic Tomcod, Bay Anchovy, Blueback Herring, Gizzard Shad, Hogchoker, Rainbow Smelt, Shortnose Sturgeon, Spottail Shiner, Striped Bass, Weakfish, White Catfish, and White Perch
1997-2017	Alewife, American Shad, Atlantic Sturgeon, Atlantic Tomcod, Bay Anchovy, Blueback Herring, Bluefish, Gizzard Shad, Hogchoker, Rainbow Smelt, Shortnose Sturgeon, Spottail Shiner, Striped Bass, Weakfish, White Catfish, and White Perch

The LRS spanned the entire HRE (Figure 1), from the Battery to the Troy dam (RM 0-152). However, prior to 1988, surveying only included Yonkers through part of Albany (RM 12-120). Stratified random sampling was used to determine the sampling locations. The HRE was divided into 13 regions (Figures 1 & 2), and each region was further divided into strata based on river depth (Figure 3). The three strata were shoal (water of 6 meters m or less), bottom (water within 3 m of the river bottom in greater than 6 m depth), and channel (water more than 3 m from the river bottom in more than 6 m depth). A minimum of two samples per stratum per region were targeted for sampling. However, some regions were skipped during certain weeks because few targeted species had historically been found in those regions at that time (Table 2).

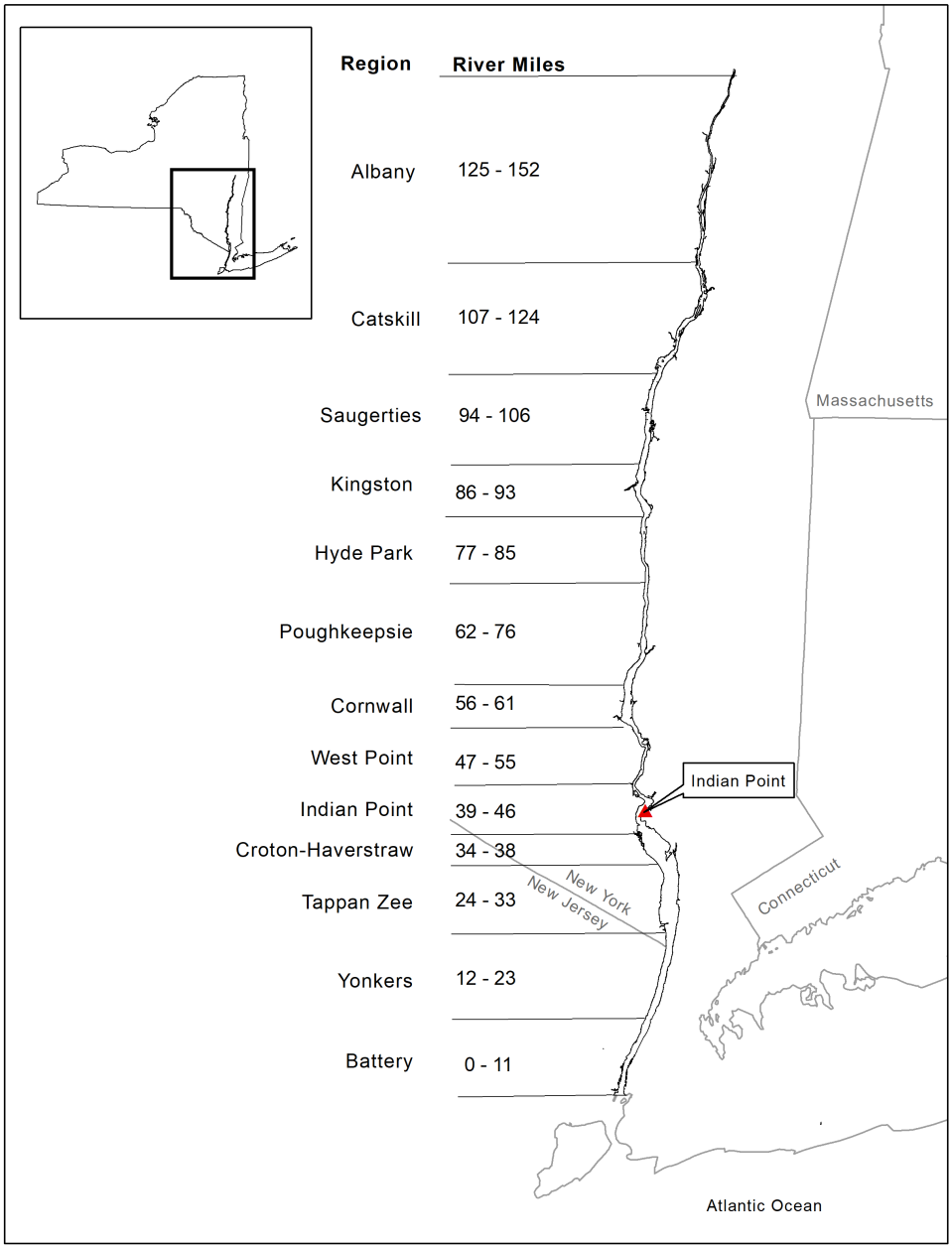

Figure 1. Map depicting the 13 geographic river regions of the HRE sampled by the LRS.

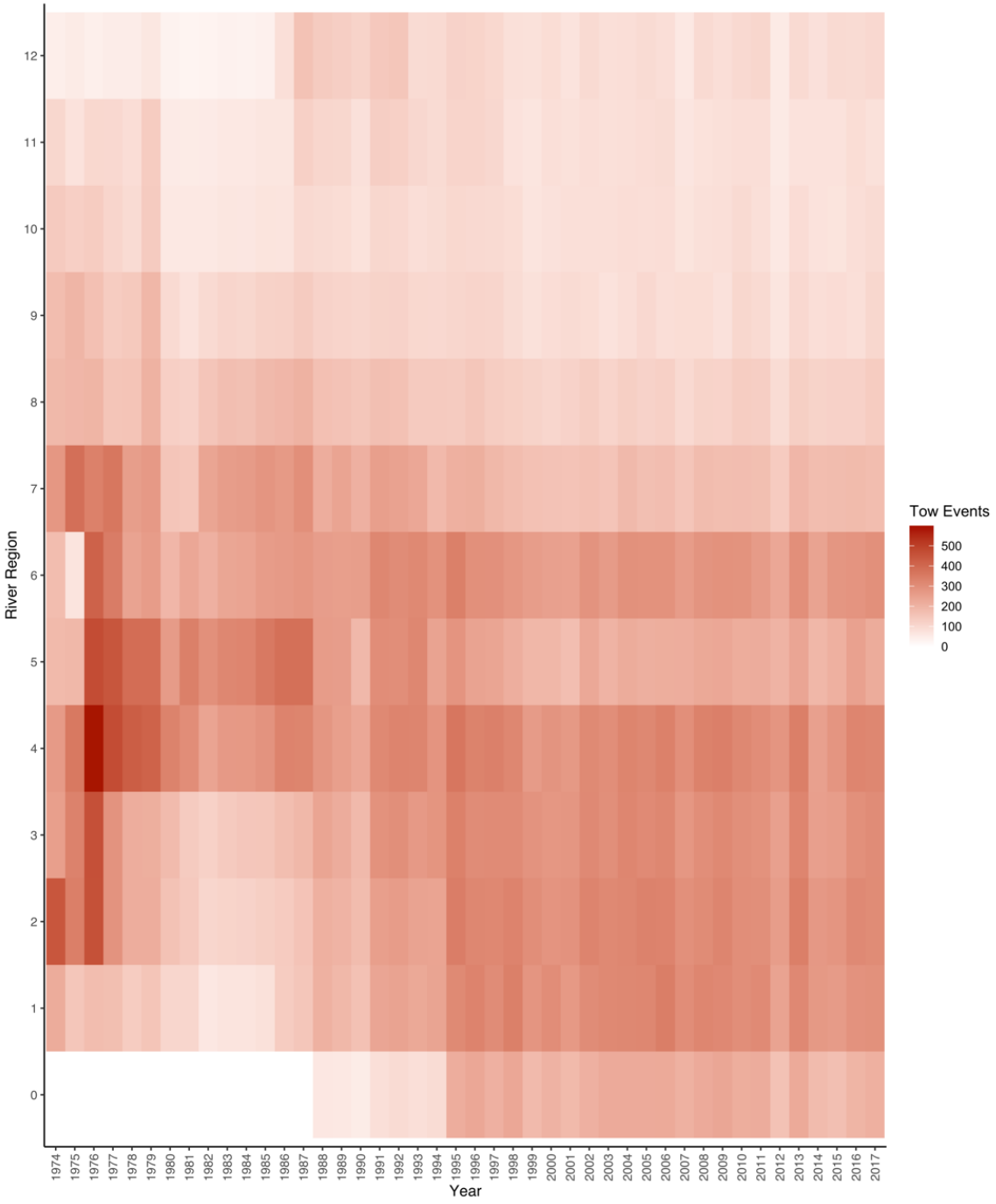

Figure 2. This heat map shows the sampling intensity of the thirteen Hudson River Estuary regions (y-axis) for each year of the LRS (x-axis). Each box represents one river region for one year, and the color of the box represents the number of times a tow was successfully completed in that region that year. The darker the red indicates a greater number of tow events and white indicates there were zero tows successfully completed in that region for that year.

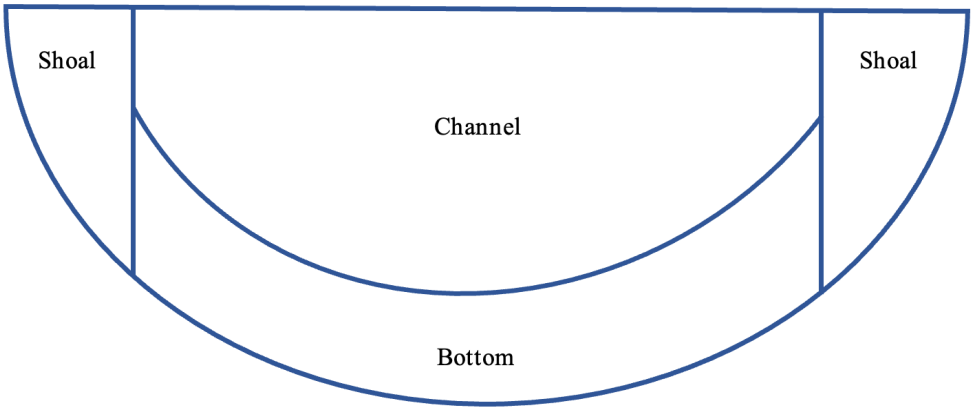

Figure 3. Cross section of the HRE showing the three strata sampled, based on river depth. Shoal is waters of 6 meters (m) or less; Bottom is water within 3-m of the river bottom in water greater than 6-m depth; and Channel is water more than 3-m from the river bottom in water more than 6-m depth. The strata were further broken down into West of Channel (≤ 6-m depth), Channel (> 6-m depth), and East of Channel (≤ 6-m depth).

Table 2. Strata sampled within the 13 river regions of the HRE. Note: A indicates strata that were sampled in all years of the LRS, B indicates strata sampled in 1985 and later years, and -- indicates strata that were not sampled.

Region	Abbreviation	River Miles	River Kilometers	Shore	Shoal	Channel	Bottom
Battery	BT	1-11	1-19	--	--	B	B
Yonkers	YK	12-23	19-39	A	A	A	A
Tappan Zee	TZ	24-33	39-55	A	A	A	A
Croton-Haverstraw	CH	34-38	55-63	A	A	A	A
Indian Point	IP	39-46	63-76	A	A	A	A
West Point	WP	47-55	76-90	A	--	A	A
Cornwall	CW	56-61	90-100	A	A	A	A
Poughkeepsie	PK	62-76	100-124	A	--	A	A
Hyde Park	HP	77-85	124-138	A	--	A	A
Kingston	KG	86-93	138-151	A	--	A	A
Saugerties	SG	94-106	151-172	A	--	A	A
Catskill	CS	107-124	172-201	A	--	A	A
Albany	AL	125-152	201-246	A	--	A	A

Sampling initially occurred mid-April through mid-August but was later expanded to mid-March through mid-October (Figure 4). During the sampling season, surveys were conducted on either a weekly or bi-weekly basis. The LRS performed weekly sampling during the summer (mainly from May to July) when most early life stages occur, and biweekly sampling after the spawning and hatching season of most of the targeted species (mainly August to October, but not for all years). Day sampling (defined as 30 minutes after sunrise to 30 minutes before sunset) and night sampling (defined as 30 minutes after sunset to 30 minutes before sunrise) occurred from 1974-1986, only night sampling from 1987-1994, and day and night sampling for the remainder of the survey (Figure 5).

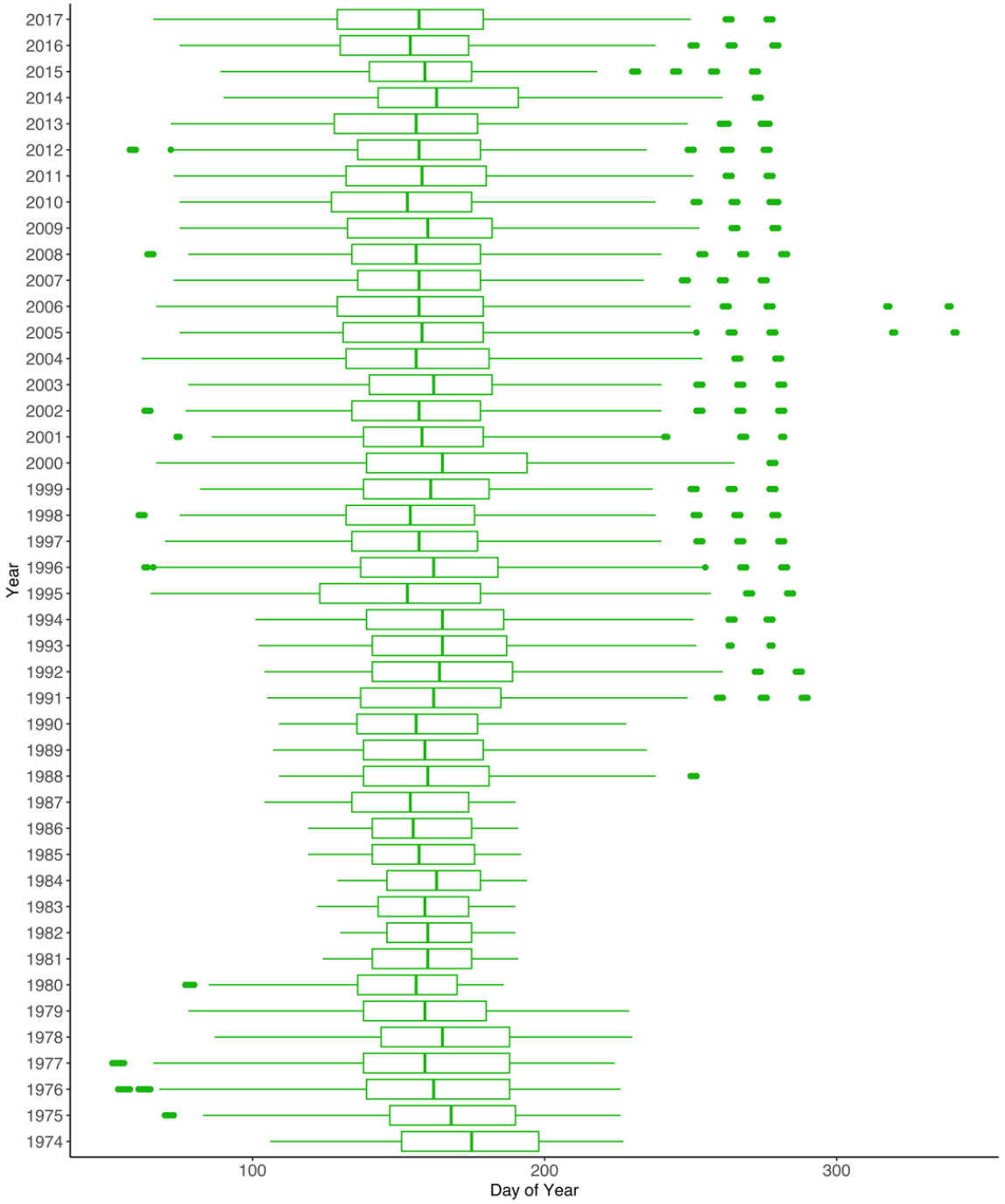

Figure 4. This box plot shows the distribution of tow events across each day of year (DOY; x-axis) for each year of the LRS (y-axis), where day of year 1 = January 1. The lower and upper day of year values of the boxes are the first (Q1) and third (Q3) quartiles (25th and 75th percentiles). The difference between Q1 and Q3 is interquartile range (IQR). The whiskers extend to 1.5 times the IQR from Q1 or Q3. Any tows that occurred on DOY outside the box and whisker values for a given year are shown by individual dots. The vertical line with each box represents the median DOY of sampling.

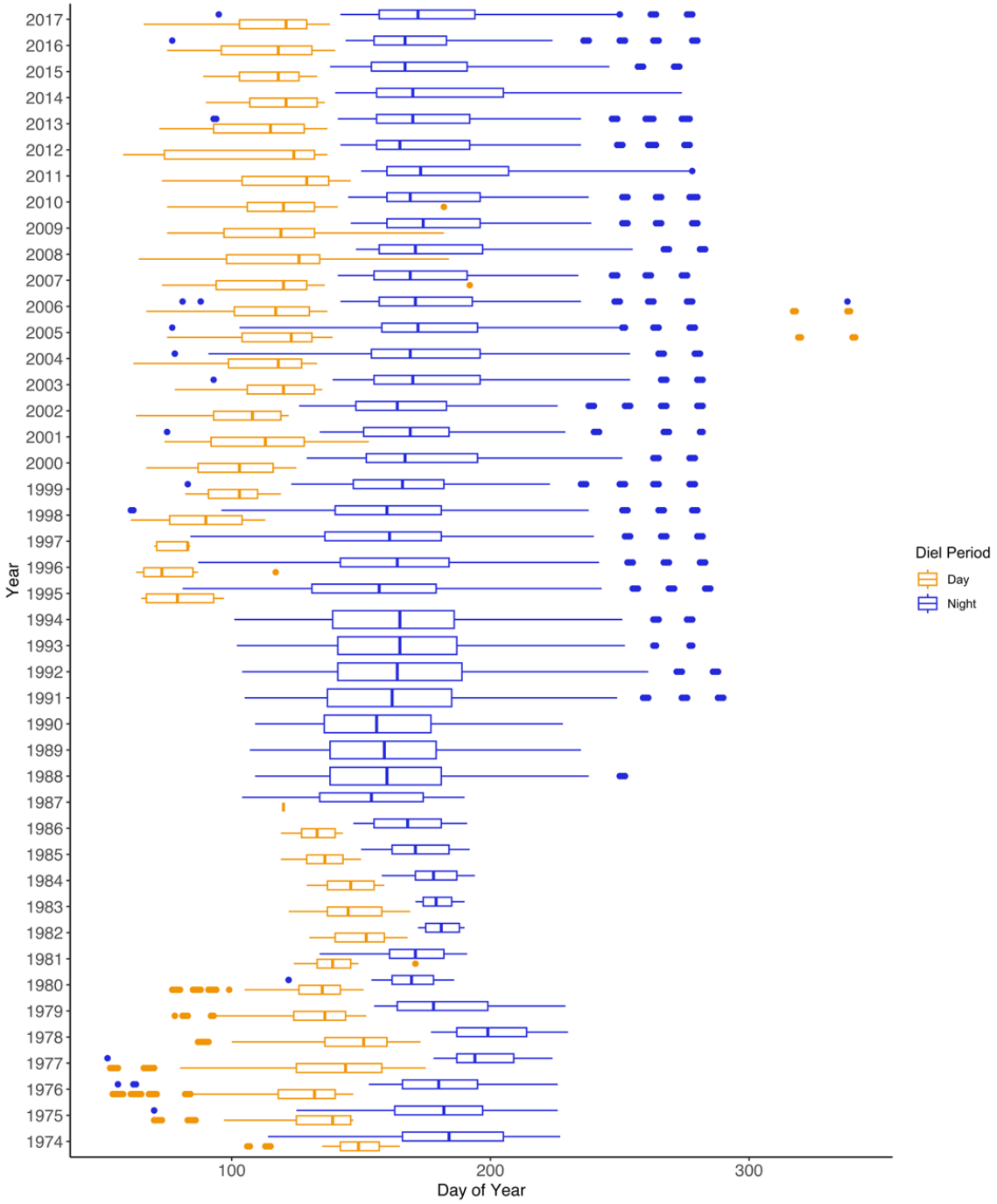

Figure 5. This box plot shows the distribution of tow events across each day of year (DOY; x-axis) for each year of the LRS (y-axis), where day of year 1 = January 1, separated by tows conducted during the day (yellow) and during the night (dark blue). The lower and upper day of year values of the boxes are the first (Q1) and third (Q3) quartiles (25th and 75th percentiles). The difference between Q1 and Q3 is interquartile range (IQR). The whiskers extend to 1.5 times the IQR from Q1 or Q3. Any tows that occurred on DOY outside the box and whisker values for a given year during a specified diel period are shown by individual dots. The vertical line with each box represents the median DOY of sampling for each diel period.

Two types of gear were used for surveying: an epibenthic sled and a Tucker trawl (Table 3 & Figure 6). The epibenthic sled was rigged with plankton nets (500 or 505 micrometer [μm] mesh) and used to sample the bottom and shoal strata (Table 3 & Figure 6). The Tucker trawl was rigged with opening and closing plankton nets (500 μm mesh) and was used to sample channel and shoal strata (Table 3 & Figure 6). Both gears were towed against the current for a duration of five minutes. The tow speed for the Tucker trawl was adjusted to maintain a towing wire angle of approximately 45 degrees averaging approximately 0.9 m/second. In general, the Tucker trawl sampled depths 3-8 m, and the epibenthic sled sampled depths 8-15 m.

From 1974 to 1981, in situ measurements of water temperature (°C), dissolved oxygen (mg/L), and conductivity (microsiemens/cm at 25°C) were taken at depths associated with the collection of LRS samples. One water sample was collected for each new tow at approximately the same depth as the tow. Beginning in 1982, and continuing through 2017, water quality measurements were dissociated from the sample collections of the LRS and FJS and instead were collected at 65 fixed stations at approximately three-mile intervals along the length of the HRE.

Table 3. Characteristics of sampling net and collection cup used on 1-m^2 Tucker trawl and 1-m^2 epibenthic sled used in LRS program.

Characteristic	Description
Sampling Net	
Length	8.0 m
Mouth (width)	1.0 m
Mouth (height)	1.4 m
Mesh size	500 or 505 μm
Net material	Nytex (monofilament nylon)
Collection Cup	
Length	30 cm
Length with net-retaining ring	37 cm
Mesh size	500 μm
Net material	Nytex (monofilament nylon)

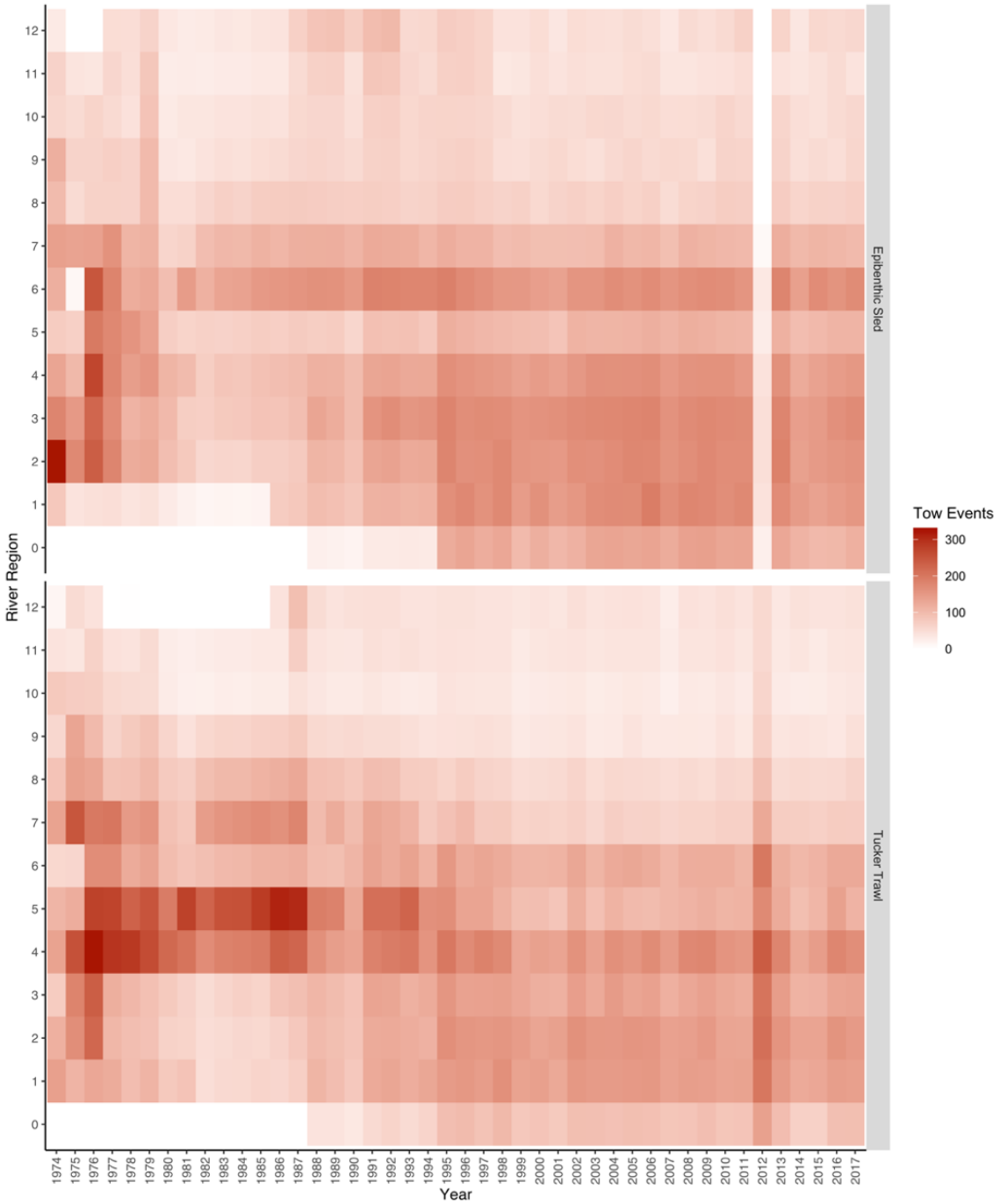

Figure 6. This heat map shows the sampling intensity of the thirteen Hudson River Estuary regions (y-axis) for each year of the LRS (x-axis) separated by the two gears used for the LRS: epibenthic sled and Tucker trawl. Each box represents one river region during one year for the specified gear, and the color of the box represents the number of times a tow was successfully completed in that region that year. The darker the red indicates a greater number of tow events and white indicates there were zero tows successfully completed in that region for that year.

1.2 Sampling Restrictions

Ichthyoplankton sampling was not permitted when water temperature was higher than 28°C and when dissolved oxygen (DO) was below 4.5 milligram per liter at the approximate depth fished by the sampling gear. Adherence to this requirement was based on measurements at the 65 standard water quality stations. At the start of each sampling day, before the first deployment of ichthyoplankton sampling gear, water temperature and DO were measured at the water quality station within or closest to the river mile in which sampling is scheduled to begin. If temperature and DO were both within the specified limits, sampling proceeded as scheduled until reaching the next river mile segment that contained the next standard water quality station(s). However, if either the temperature or DO was not within the acceptable range, sampling was not conducted until acceptable values were encountered in a subsequent water quality station. Each time the sampling vessel entered another river mile segment that contained one or more standard water quality stations, water quality measurements were taken before any additional towing, to determine whether the temperature and DO were both within acceptable limits. These restrictions were in accordance with the terms and conditions of the National Marine Fisheries Service (NMFS) Permit to Take Protected Species for Scientific Purposes Permit and the New York State Department of Environmental Conservation (NYSDEC) Endangered/Threatened Species.

2. Sample Processing

2.1 Field Processing

Once towing was complete, the gear was retrieved, and nets were washed down from the outside with river water to concentrate the sample in the collection cup. To remove excess water, the contents of the collection cup were transferred to a sieve of equal or finer mesh. All yearling and adult fish were identified, counted, sorted by length class (Table 4), and returned to the water alive, if possible. The remaining sample was placed in a container and filled completely with 10% aqueous formalin solution. Samples collected for aging were processed in the same manner as the regular LRS samples but were preserved in 95% ethyl alcohol. All samples collected were brought back to the lab for additional processing and/or analysis.

Table 4. Length class divisions (total length [TL]) and definitions.

Length Class	Definition
One	Less than or equal to the YOY length limit ("Division 1"), Division 1 is the species-specific upper length limit for YOY
Two	Greater than Division 1 and less than or equal to the yearling length limit ("Division 2"), Division 2 is the upper length limit for yearlings of key species and 150 mm for others
Three	Greater than Division 2 and less than or equal to 250 mm
Four	Greater than 250 mm

2.2 Lab Processing

At the lab, samples were sorted and analyzed. To help with sorting, samples may have been stained with rose bengal. The samples were sieved with mesh equal or finer than 375 microns and rinsed with water to remove the preservative. The samples were then washed into a container

from the sieve. Selection of samples for lab analysis started by grouping the samples according to river run, region, and strata. Based on these groupings, samples were selected based on the following criteria:

1. If there were less than 6 samples in the group, all samples were selected for analysis.
2. If there were between 6-12 samples in the group, then 50% of the samples were randomly selected for analysis.
3. If there were more than 12 samples in the group, then 20% of the samples were randomly selected for analysis.

Samples with a large volume were subsampled using a splitting method. The number of times a sample was split was determined by the total material in the sample. Samples containing a large number of eggs may have been split so that eggs were only sorted from one or more aliquots containing a total of at least 250 eggs (all species combined). Two different criteria were used for subsampling larval stages depending on the river run:

1. Starting with the river run in which Striped Bass post-yolk-sac-larvae (PYSL) first appear, and for the next eight river runs (nine total consecutive), a minimum of 500 *Morone* larvae (i.e., combined total of yolk-sac-larvae [YSL], PYSL, YOY of Striped Bass and White Perch, and identified *Morone*) must be sorted from the sample and a minimum of 50 non-Morone larvae must be sorted. Samples from these nine river runs are usually sorted in their entirety for larvae (i.e., YSL, PYSL, and YOY combined) of all species combined.
2. For the 13 river runs not covered by the first criteria (before and after the period of Striped Bass abundance), any sample from these river runs may be subsampled so that larvae are sorted from one or more splits containing at least 100 larvae (i.e., YSL, PYSL, and YOY combined) of all species combined.

Randomness of the splitting process was monitored by testing selected samples to determine whether splits from the same sample differed by more than random variation. Samples were selected to test for randomness by a continuous sampling plan. Eggs and larvae were separated from detrital material and examined under magnification, where they were identified by species and life stage, and counted. The life stages identified were egg, YSL, PYSL, and YOY (Table 5).

Table 5. Life stage designations used in identification.

Life Stage	Description
Egg	Embryonic stage from spawning to hatching
YSL	Hatching to development of a complete and functional digestive system
PYSL	Complete development of digestive system to transformation to juvenile form
YOY	Completed transformation to Age 1

When possible, a maximum of 30 Striped Bass, 30 White Perch, 30 American Shad, 30 Atlantic Tomcod, and 30 Bay Anchovy per sample were measured. Organisms were randomly chosen from each taxon regardless of life stage until the required numbers were obtained. The life stages included were YSL, PYSL, and YOY. The total length of YSL and PYSL was measured to the nearest 0.1 millimeter (mm) and YOY total length was measured to the nearest 1 mm.

3. Changes in Survey Protocols

Changes in LRS sampling protocols such as target species (Table 1), sampling periods (Figure 4), daytime/nighttime sampling (Figure 5), contractors conducting the HRBMP, and sampling locations (Figure 6) may introduce additional uncertainty in interpreting the survey data. These alterations, as well as additional sampling protocol changes, raise significant concerns over the utility and proper interpretation of the data. Changing sampling protocols could alter parameters such as catchability, complicating the interpretation of the data.

Sampling locations for species of interest were assumed to be consistent over the survey period. There were some areas in the upper (Albany region) and lower HRE (Battery region) that were not sampled during the early years of the LRS which may affect the abundance estimates of each species. Inconsistent sampling periods, such as the survey starting later and ending earlier, may result in biased estimates and loss of important information due to the survey missing parts of the peak seasons for some species. The LRS changed from daytime to nighttime sampling three weeks after the occurrence of Striped Bass eggs and to reduce gear avoidance by PYSL. The daytime and nighttime sampling switched inconsistently over the survey and in some years, there was no daytime sampling (1987-1994) which could affect the estimates of each species and their different life stages. The two gears were used approximately consistently over time and space except for a few years and a few locations. For example, in 2012 sampling with the epibenthic sled occurred in the spring and fall but not during the summer due to the sturgeon permits. Additionally, the sampling depths varied over time with only a small portion of observations collected in deeper water during the early years of the LRS.

Various data quality issues were identified including tows with multiple catch values (i.e., there were different catch data for the same species with the same tow ID), tows with catch for an unspecified species (i.e., the species was left blank for those catch data), differing use codes (see the LRS Data Dictionary), no absence data (i.e., only presence data was recorded), and codes included in variables that are not defined in existing HRBMP data dictionaries.

For additional details on LRS survey protocol changes refer to the associated LRS Timeline Excel spreadsheet. For the data availability (i.e., years available) for each variable see Table 6.

Table 6. Data availability for each variable collected by the LRS.

Variable	Years Available
CALIB_DT	1991–2017
CATCH_CD	1974–2017
CONDUCTIVITY	1974–1981
CT_EGGS	1974–2017
CT_OLDER	1974–2017
CT_OLDER_corrected	1974–2017
CT_PYSL	1974–2017
CT_UNID	1974–2017
CT_YOY	1974–2017

CT_YOY_corrected	1974–2017
CT_YR_OL	1974–2017
CT_YRLNG	1974–2017
CT_YRLNG_corrected	1974–2017
CT_YROL_corrected	1974–2017
CT_YSL	1974–2017
DATE	1974–2017
DISSOLVED.OXYGEN	1974–1981
DIVISION.1.CUTOFF	1980–2017
DIVISION.2.CUTOFF	1980–2017
DURATION	1974–2017
FISH_ID	1976–1987, 1992–2017
FLOWMETER.DIFFERENCE	1974–2017
FLOWMETER.END	1974–2017
FLOWMETER.NUMBER	1974–2017
FLOWMETER.START	1974–2017
GEAR.CODE	1974–2017
LAT.DEGREE	2002–2017
LAT.MINUTE	2002–2017
LENGTH	1976–1977, 1979–2017
LIFE_STG	1976–2017
LON.DEGREE	2002–2017
LON.MINUTE	2002–2017
NET.LENGTH.OPENING.WIDTH.RATIO	1974–2017
NET.MESH	1974–2017
PH	1974–1978
PRESERVATION.METHOD	1986–1987, 1991–2017
PROCESSING.DATE	1980–1981
QC_OLDER	1990
QC_YOY	1990
QC_YR_OL	1990
QC_YRLING	1990
RIVER.DEPTH	1974–2017
RIVER.MILE	1974–2017
RIVER.RUN	1974–2017
SAM_NARR	1980–2017
SAMPLE.DEPTH.m	1974–2017
SAMPLE.NUMBER	1974–2017
SITE	1974–2017

SPLIT_CD	1980–1981, 1983–1987
SPLIT_CD_lv4	1981
SPLIT_CD_lv4	1981
STRATA.CODE	1974–2017
TASK_CD	1974–2017
TAXON.CODE	1974–2017
TIDE.STAGE	1974–2017
TIME	1974–2017
TOTAL.COUNT.IN.LENGTH.CLASS.1	1980–2017
TOTAL.COUNT.IN.LENGTH.CLASS.2	1980–2017
TOTAL.COUNT.IN.LENGTH.CLASS.3	1980–2017
TOTAL.COUNT.IN.LENGTH.CLASS.4	1980–2017
TOW.DIRECTION	1980–2017
TOW.SPEED	1974–2017
TURBIDITY	1974–1978
USE.CODE	1980–2017
VESSEL.CODE	1974–2017
VOLUME.OF.WATER.SAMPLED.IN.CUBIC.METERS	1974–2017
WATER.QUALITY.SAMPLE.DEPTH	1974–2017
WATER.TEMPERATURE	1974–2017
WAVE.HEIGHT	1974–2017
YEAR.OF.DATA.COLLECTION	1974–2017