A year and a Hurricane Apart: Nutrient Loading in the St. Lucie Estuary in the Summers of 2016 and 2017

Ian Walsh
October 3, 2017 / SECOORA Webinar Series

This presentation could and would not happen without the expertise and hard work of Dr. Dennis Hanisak and Kristen Davis and their team.
They keep IRLON funded and running, and we all benefit.
Dennis and Dr. Brian Lapointe contributed their understanding of the estuary in multiple conversations.

Data are presented courtesy of Indian River Lagoon Observatory Network of Environmental Sensors fau.loboviz.com
Got muck? Florida residents can report algae blooms with new hotline.

After declaring a state of emergency this week, Florida officials have turned to citizens to help control the outbreak.

By APNewsNow, Associated Press | JULY 8, 2016

TALLAHASSEE, Fla. (AP) — The state has launched a hotline to help residents give updates on the massive algae bloom fouling some of Florida's southern rivers and beaches.

Residents can call a toll-free at 1-855-355-3903 or report information online at www.reportalgalbloom.com. The smelly muck comes just in time for the holiday weekend.
What We Will Cover Today

• Estuaries and Biogeochemical Processes
  • Sources
• IRLON sites in the St. Lucie Estuary
  • How I got the data
• Nutrients in the summer of 2016:
  • Blue green algae bloom
• Nutrients in the summer of 2017
• September 2017:
  • Irma
IRLON Locations
An Estuary acts like a big mixing tub, with energy and materials supplied by fresh water running down hill and seawater driven by the Moon.
Structure and Flow
Water Flows Down Hill
Water Flows Down Hill
Water Flows Down Hill
Water Flows Down Hill
Tides and Storms change the gradient

- Storm Surge
- High Tide
- Low High Tide
- Sea Level
- High Low Tide
- Low Tide
Tides and Storms change the gradient

Rainfall
Outflow
Runoff

Storm Surge
High Tide
Low High Tide
Sea Level
High Low Tide
Low Tide
Plants Growth: Light, Nutrients, Time

Fort Pierce, Florida, United States - Sunrise, sunset, dawn and dusk times, graph

(c) Gaisma.com


Plenty of light in Florida
Warm Year Round, Wet Summers

Fort Pierce, **Florida, United States** - Solar energy and surface meteorology

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These data were obtained from the NASA Langley Research Center Atmospheric Science Data Center; New et al. 2002

Notes: [Help](#), Change [preferences](#)

The ocean is salty

http://www.oao.obs-vlfr.fr/bioargo/PHP/lovbio006b/lovbio006b.html
The surface ocean is very low in organics and nutrients

http://www.oao.obs-vlfr.fr/bioargo/PHP/lovbio006b/lovbio006b.html
Estuary Flow Tracers

• Fresh Water: Colored Dissolved Organic Matter
  • Decayed organic matter
  • High nutrients

• Ocean Water
  • Salts: Salinity
  • Low nutrients
IRLON Data Access: SECOORA

The Southeast Coastal Ocean Observing Regional Association (SECOORA) is a regional non-profit organization based in Charleston, South Carolina and operating in the coastal waters of NC, SC, GA and FL. SECOORA is one of the eleven coastal ocean observing regional associations partnered with the US Integrated Ocean Observing system (US IOOS).

SECOORA’s data management and communications (DMAC) system implements the US IOOS recommended standards-based web services that promote interoperability, discovery, efficient data aggregation, access, sharing, visualization, and use of coastal ocean data (physical, chemical, biological and geological). This data catalog contains searchable, downloadable data from all SECOORA-funded observational and modeling assets that include coastal and offshore stations (atmospheric and oceanographic data), IOOS Priority High Frequency Radar Stations, regional and sub-regional coastal circulation, water quality and fisheries habitat models. The catalog also aggregates data from federal and non-federal real-time and non-real time coastal ocean datasets (in-situ, gliders, profilers, drifters, satellite and models) in the SECOORA region.

Search Data Catalog
Launch Interactive Map

portal.secoora.org
IRLON Data Access: SECOORA

portal.secoora.org
IRLON Data Access: SECOORA

Interactive Map
IRLON Data Access

LATEST. Click site name for data.

WEATHER

JRL-EP Indian River Lagoon - Link Port
2017-02-28 14:00:00 EST

JRL-JB Indian River Lagoon-Jensen Beach
2017-02-28 14:00:00 EST

JRL-SLE Indian River Lagoon-St. Lucie Estuary
2017-02-28 14:00:00 EST

SLST-EP St. Lucie Estuary-Middle Estuary
2017-02-28 14:00:00 EST

SLST-EP St. Lucie Estuary-North Fork
2017-02-28 14:00:00 EST

SLST-EP St. Lucie Estuary-South Fork
2017-02-28 14:00:00 EST

SLST-EP St. Lucie Estuary-South Fork 2
2017-02-28 14:00:00 EST

WATER QUALITY

JRL-EP Indian River Lagoon - Link Port
2017-02-28 14:00:00 EST

JRL-EP Indian River Lagoon - Fort Pierce
2017-02-28 08:00:00 EST

JRL-VB Indian River Lagoon - Vero Beach
2017-02-23 07:00:00 EST

JRL-SB Indian River Lagoon - Sebastian
2017-02-29 14:00:00 EST

JRL-JB Indian River Lagoon-Jensen Beach
2017-02-29 14:00:00 EST

JRL-SLE Indian River Lagoon-St. Lucie Estuary
2017-02-29 14:00:00 EST

SLST-EP St. Lucie Estuary-Middle Estuary
2017-02-29 14:00:00 EST

FAU Harbor Branch Indian River Lagoon Observatory

The Indian River Lagoon (IRL) is situated along 156 miles of Florida's east coast. Urbanization, excessive freshwater releases, degradation of water quality, contaminant loading, loss of habitat (e.g., seagrasses, mangroves), harmful algal blooms, decline of fisheries, and emerging diseases in marine mammals and other BTOs are increasingly important issues in the IRL, as they are throughout the world's estuaries and coastal waters. The Indian River Lagoon Observatory (IRLO), based at Florida Atlantic University's Harbor Branch Oceanographic Institute, is conducting long-term, multi-disciplinary, ecosystem-based research on this nationally significant estuary.

IRLO research and education activities are being enhanced by the deployment of an estuarine observation network of land/ocean biogeochemical observatory (LOBO) units and weather sensors to provide real-time, high-accuracy and high-resolution water quality/weather data through this dedicated interactive website. The LOBO network enables researchers to follow environmental changes in the IRL, assist resource and planning managers in decision-making, and correlate environmental data with chemical and physical phenomena, and contribute to public outreach on the lagoon.

Currently LOBOs are deployed at nine sites in the Estuary (SLE). Four sites in Indian River County:
IRLON Data Access

LOBO - Land/Ocean Biogeochemical Observatory

Latest. Click site name for data.

Weather
IRL-UP Indian River Lagoon - Link Port
2017-09-29 14:00:00 EST

IRL-JB Indian River Lagoon-Jensen Beach
2017-09-29 14:00:00 EST

SLE-ME St. Lucie Estuary-Middle Estuary
2017-09-29 14:00:00 EST

SLE-NF St. Lucie Estuary-North Fork
2017-09-29 14:00:00 EST

SLE-SF St. Lucie Estuary-South Fork
2017-09-29 14:00:00 EST

SLE-SP2 St. Lucie Estuary-South Fork 2
2017-09-29 14:00:00 EST

Water Quality
IRL-UP Indian River Lagoon - Link Port
2017-09-29 14:00:00 EST

IRL-FP Indian River Lagoon - Fort Pierce
2017-09-20 08:00:00 EST

IRL-VB Indian River Lagoon - Vero Beach
2017-09-21 07:00:00 EST

IRL-S8 Indian River Lagoon - Sebastian
2017-09-29 14:00:00 EST

IRL-JB Indian River Lagoon - Sebastian
2017-09-29 14:00:00 EST

IRL-EL Indian River Lagoon - Sebastian
2017-09-29 14:00:00 EST

The Indian River Lagoon Observatory Network
of Environmental Sensors

The Indian River Lagoon (IRL) is situated along 156 miles of Florida's east coast. Urbanization, excessive freshwater releases, degradation of water quality, nutrient loading, loss of habitat (e.g., seagrasses, mangroves), harmful algal blooms, decline of fisheries, and emerging diseases in marine mammals and other biota are increasingly important issues in the IRL, as they are throughout the world's estuaries and coastal waters. The Indian River Lagoon Observatory (IRLO), based at Florida Atlantic University's Harbor Branch Oceanographic Institute, is conducting long-term, multi-disciplinary, ecosystem-based research on this nationally significant estuary.

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Currently LOBOs are deployed at nine sites in the Estuary (SLE). Four sites in Indian River County:

Fau.loboviz.com
LOBOviz: Downloading

Latest. Click site name for data.

**Weather**
- IRL-LP Indian River Lagoon - Link Port 2017-09-29 14:00:00 EST
- IRL-LJ Indian River Lagoon-Jensen Beach 2017-09-29 14:00:00 EST
- IRL-SLE Indian River Lagoon-St. Lucie Estuary 2017-09-14 09:00:00 EST
- SLE-ME St. Lucie Estuary-Middle Estuary 2017-09-28 14:00:00 EST
- SLE-NF St. Lucie Estuary-North Fork 2017-09-29 14:00:00 EST
- SLE-SF St. Lucie Estuary-South Fork 2017-09-29 14:00:00 EST
- SLE-SF2 St. Lucie Estuary-South Fork 2 2017-09-29 14:00:00 EST

**Water Quality**
- IRL-LP Indian River Lagoon - Link Port 2017-09-29 14:00:00 EST
- IRL-LF Indian River Lagoon - Fort Pierce 2017-09-29 08:00:00 EST
- IRL-VC Indian River Lagoon - Vero Beach 2017-09-21 07:00:00 EST
- IRL-BJ Indian River Lagoon - Sebastian 2017-09-29 14:00:00 EST
- IRL-LJ Indian River Lagoon-Jensen Beach 2017-09-29 14:00:00 EST
- IRL-SLE Indian River Lagoon-St. Lucie Estuary 2017-09-14 09:00:00 EST
- SLE-ME St. Lucie Estuary-Middle Estuary

**LOBOviz**

Select an X-axis variable, one or more Y-axis variables, and the desired date range. Then press the plot button to view the data set.

**Site(s)**
- [ ] IRL-LP
- [ ] IRL-LF
- [ ] IRL-VC
- [ ] IRL-BJ
- [ ] IRL-LJ
- [ ] SLE-ME
- [ ] SLE-NF
- [ ] SLE-SF
- [ ] SLE-SF2

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- [ ] date
- [ ] day number
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- [ ] depth of instrument [m]
- [ ] depth of instrument [ft]
- [ ] dissolved O2 [mL/L]
- [ ] nitrate [µM]
- [ ] nitrate [mg/L]
- [ ] O2 saturation [%]
- [ ] pH
- [ ] phosphate concentration [µM]
- [ ] phosphate concentration [mg/P/L]
- [ ] pressure [bar]
- [ ] salinity
- [ ] temperature [ºC]
- [ ] turbidity [NTU]

**Y Variable(s)**
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**Date Range**
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- [ ] day of End date
- [ ] 3 days ending on End date
- [ ] week ending on End date
- [ ] month ending on End date
- [ ] specify Start and End dates

Specify dates:
- **Start:**
  - Jan. 17
- **End:**
  - Jan. 29

[Plot the data] [Reset]
**LOBOviz: Downloading**

### Latest

**Weather**
- IRL-LP Indian River Lagoon - Link Port 2017-09-29 14:00:00 EST
- IRL-JB Indian River Lagoon-Jensen Beach 2017-09-29 14:00:00 EST

**Water Quality**
- IRL-LP Indian River Lagoon - Link Port 2017-09-29 14:00:00 EST
- IRL-EP Indian River Lagoon - Fort Pierce 2017-09-29 14:00:00 EST
- IRL-VP Indian River Lagoon - Vero Beach 2017-09-29 14:00:00 EST
- IRL-SB Indian River Lagoon - Sebastian 2017-09-29 14:00:00 EST
- IRL-JB Indian River Lagoon - Jensen Beach 2017-09-29 14:00:00 EST

### LOBOviz

Select an X-axis variable, one or more Y-axis variables, and the desired date range. Then press the plot button to view the data set.

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### X Variable
- **date**
- **day number**
- **Conductivity (S/m)**
- **Depth of instrument [m]**
- **Dissolved O₂ [ml/l]**
- **Nitrates [µm]**
- **Silicon [µm]**
- **O₂ saturation [%]**
- **Temperature [°C]**
- **Turbidity [NTU]**

### Variable(s)
- **CDOM [Q/µE]**
- **Chlorophyll [µg/l]**
- **Current direction [°]**
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- **Salinity [%]**
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- **Pressure [mbar]**
- **Wind speed [m/s]**

### Date Range
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- **End:** 2017-09-30

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**Unclick all but one site**

**Select the data**
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Set the time range
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©2014 Sea-Bird Scientific Inc.
Got muck? Florida residents can report algal blooms with new hotline.

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By APNewsNow, Associated Press | JULY 5, 2016

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Residents can call a toll-free at 1-855-305-3903 or report information online at www.reportalgabloom.com. The smelly muck comes just in time for the holiday weekend.
Flow Sources

Figure 2. South Florida Water Management District control structures providing flow to the St. Lucie River Estuary.

Flow From Lake

2016 S-308 Discharge (ft³/sec)

https://waterdata.usgs.gov/fl/nwis/wys_rpt/?site_no=02276877&agency_cd=USGS
Three Water Sources

Salinity v CDOM: January 2016 - May 2016

- Seawater
- Runoff
  - Other Freshwater Sources

Lake Okeechobee
Wet January: Runoff

Salinity v CDOM: January 2016

Runoff
- Other Freshwater Sources
Estuary Flow Tracers

• Fresh Water: Colored Dissolved Organic Matter
  • Decayed organic matter
  • High nutrients

• Ocean Water
  • Salts: Salinity
  • Low nutrients
Nutrient Concentration and Sources

- Ocean
  - Salinity: 35 PSU
  - CDOM: 10 ppb QSDE
  - Phosphate: < 1 μM

- Lake Okeechobee
  - Salinity: < 1 PSU
  - CDOM: 60 ppb QSDE
  - Phosphate: 1 μM

- Runoff
  - Salinity: 10 PSU
  - CDOM: 100 ppb QSDE
  - Phosphate: > 6 μM

- IRLON data during this event confirms previous work
Previous Work

Effects of Hurricanes, Land Use, and Water Management on Nutrient and Microbial Pollution: St. Lucie Estuary, Southeast Florida

Brian E. Lapointe, Laura W. Herren, and Bradley J. Bedford

Marine Ecosystem Health Program
Harbor Branch Oceanographic Institute
Florida Atlantic University
5660 U.S. Highway 1 North
Pt. Pierce, FL 34946, U.S.A.
blapcin1@hboi.fiu.edu

ABSTRACT


Multiple hurricanes impacted southeast Florida during 2004 and 2005, producing record rainfall and large-scale stormwater runoff into the urbanized St. Lucie Estuary (SLE). To assess effects on water quality, field samples were taken in June and November 2005 and March 2006 along the SLE’s three main segments: the South Fork, connected via the C-44 canal to Lake Okeechobee; the North Fork, which receives residential and agricultural runoff from the C-23 and C-24 canals; and the Middle Estuary, which flows into the Indian River Lagoon and Atlantic Ocean. Salinities were <1% throughout the normally brackish estuary during the 2005 sampling, but returned to near-normal levels by March 2006 in all but the South Fork. Low salinities in 2005 correlated with low dissolved oxygen, high turbidity, elevated nitrogen and phosphorus concentrations, and high fecal and total coliform counts. Highest turbidity (84.4 NTU), nitrate (37.9 μM), and total dissolved nitrogen (130.8 μM) concentrations occurred in the South Fork, whereas the highest ammonium (15.4 μM), soluble reactive phosphorus (10.5 μM), and total dissolved phosphorus (13.8 μM) concentrations occurred in the North Fork. High fecal and total coliform counts occurred in tidal creeks adjacent to dense residential areas that rely on septic tanks for on-site sewage disposal. The data suggest that increased stormwater retention, minimization of freshwater releases from Lake Okeechobee, and enhanced treatment of both stormwater and sewage are needed to mitigate future stormwater-driven water quality perturbations in the SLE.

ADDITIONAL INDEX WORDS: Rainfall, stormwater, salinity, nitrogen, phosphorus, coliform, bacteria.

INTRODUCTION

The St. Lucie Estuary (SLE) comprises one of the largest estuaries on the east coast of Florida and is a primary tributary.

SLE had a relatively small natural watershed. However, the network of locks and water control structures constructed during the past century to allow drainage for expanding urban growth and agriculture has artificially enlarged that
Evidence of sewage-driven eutrophication and harmful algal blooms in Florida's Indian River Lagoon

Brian E. Lapointe *, Laura W. Herren, David D. Debor, toli, Margaret A. Vogel
Harbor Branch Oceanographic Institute at Florida Atlantic University, Harmful Algal Bloom Program, 3800 US 1 North, Port Pierce, FL 34983, USA

Abstract

Nutrient pollution is a primary driver of eutrophication and harmful algal blooms (HABs) in estuaries and coastal waters worldwide. In 2011–2012, 20 sites evenly distributed throughout the 551-km long Indian River Lagoon (IRL) were assessed during three sampling events for dissolved nutrients (DON, SRP, TN, TDP) and chlorophyll a. Benthic macroalgae were also analyzed for 813C, 815N, and C:N:P contents to identify potential nutrient sources and gauge the type and degree of N and P limitation. The mean DON and SRP concentrations throughout the IRL were high, averaging 4.24 ± 0.45 and 0.68 ± 0.06 μM, respectively, explaining the widespread occurrence of HABs during the study. High TDP concentrations (up to 152 μM) and TN:TDP ratios (>100:1) in the poorly flushed northern IRL, Mosquito Lagoon and Banana River segments reflected the accumulation and cycling of N-rich groundwater inputs that produce P-limitation. These enriched nutrient conditions were associated with unprecedented chlorophyll a concentrations (>100 μg L⁻¹), dominated by A. tamarensis D.A. Liddell, DeVries, Hagavrom and P.W. Johnson in the Mosquito Lagoon and northern IRL in 2012. C:N, C:P, and N:P ratios in macroalgae averaged 15.5, 698.9, and 49.8 throughout the
2015 MARTIN COUNTY WATERSHED TO REEF SEPTIC STUDY

FINAL REPORT

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For:
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Martin County Utilities Department
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March 4, 2016
Nutrient Loads At the IRLON Sites

• Phosphate and Nitrate In Situ Data
• Redfield Ratios:
  • Molar Ratio of Phytoplankton: Single cell plants in water
  • 16 Atoms of Nitrogen (N, NO₃) for every atom of Phosphorus (P, PO₄)
• Blue Green Algae tend to out-compete when phosphate (PO₄) is abundant
Nutrient Dynamics

SLE SF2

- phosphate
- nitrate
Nutrient Dynamics

SLE ME

- Phosphorus (µM)
- Nitrate (µM)

Date:
- 17-Jun
- 19-Jun
- 21-Jun
- 23-Jun
- 25-Jun
- 27-Jun
- 29-Jun
- 1-Jul
- 3-Jul
- 5-Jul
- 7-Jul

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Curious Spikes at the South Fork LOBO

- Positive correlations between
  - Salinity
  - CDOM
  - Phosphate
Nutrient Dynamics

![Graph showing phosphate and salinity levels over time.](image-url)
Nutrient Dynamics

SLE SF1

CDOM (ppb qSD) vs. Salinity (PSU)

Date


CDOM

Salinity

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Basin Relationships
High Discharge
Got muck? Florida residents can report algal blooms with new hotline.

After declaring a state of emergency this week, Florida officials have turned to citizens to help control the outbreak.

By APNewsNow, Associated Press | JULY 5, 2016

TALLAHASSEE, Fla. (AP) — The state has launched a hotline to help residents give updates on the massive algal bloom fouling some of Florida’s southern rivers and beaches.

Residents can call a toll-free at 1-855-305-3903 or report information online at www.reportalgalbloom.com. The smelly muck comes just in time for the holiday weekend.
Consider modulating discharge with alternating periods of high and no flow that delivers water to the north end of the south fork at the start of ebb tide. Monitor the CDOM, PO4 and salinity at SF to assure that estuarine circulation is robust.

Add phycocyanin fluorometers to all LOBOs to get early warnings of increases in the Myrocystis populations.

Build a fine scale model of the flow around the NF/SF/ME juncture that predicts basin dynamics relative to rainfall and discharge.

Consider calculating residence time in the basins as a primary factor in reducing the possibility of HABs.

Two new LOBO systems to monitor end member inputs. Also consider a LOBO to the north to monitor flow into the lake.
Consider modulating discharge with alternating periods of high and no flow that delivers water to the north end of the south fork at the start of ebb tide. Monitor the CDOM, PO4 and salinity at SF to assure that estuarine circulation is robust.
Flow From Lake

2016 S-308 Discharge (ft³/sec)

https://waterdata.usgs.gov/fl/nwis/wys_rpt/?site_no=02276877&agency_cd=USGS
Summary

• Live data from IRLON drives understanding of the estuary

• Discharges from Lake Okeechobee alter estuarine circulation

• Higher freshwater residence time and excess phosphate leads to blooms
REMARDS - Flow regulated by control structure 308 gates and lock at Lake Okeechobee. Flow frequently reverses during and after periods of heavy rainfall by pumpage into the canal from agricultural lands in the Everglades (negative figures indicate reverse flow towards Lake Okeechobee).
June-July 2017

Salinity - CDOM Relationship

Salinity (PSU) vs. CDOM (ppb QSDE)

- SF2
- SF
- NF
- ME
- SLE
CDOM - Phosphate Relationship

June-July 2017
June-July 2017

Phosphate Concentration

- SF2
- SF
- NF
- ME
- SLE

Date

Phosphate (uM)
June-July 2016

Phosphate Concentration

Phosphate (uM)

Date

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Summer 2017

• Higher nutrient concentrations did not lead to HAB event

• Residence Time – Tidal flushing is more important than nutrient loading
REMARKS - Flow regulated by control structure 308 gates and lock at Lake Okeechobee. Flow frequently reverses during and after periods of heavy rainfall by pumpage into the canal from agricultural lands in the Everglades (negative figures indicate reverse flow towards Lake Okeechobee).
CDOM - Phosphate Relationship

- SF2
- SF
- NF
- ME
- SLE

Phosphate (µM)

CDOM (ppb QSDE)
Last Week
June-July 2017

LOBO Land/Ocean Biogeochemical Observatory

scatter plot showing phosphate concentration vs. CDOM (Chlorophyll a content determined in situ by optical spectrometry). Points are color-coded by sample type: SLE-ME, SLE-NF, SLE-SF.
Last Week

--- Provisional Data Subject to Revision ---

△ Median daily statistic (55 years) — Discharge