Chemical and Biological Behavior of Carbon Nanotubes in Estuarine Sedimentary Systems

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Carbon nanotubes as environmental toxicants

- As nanomaterials, including carbon nanotubes begin to find their way into commercial and industrial applications, they will inevitably find their way into the ambient environment
- Recently, aqueous C_{60} exposure has been found to induce oxidative stress (lipid peroxidation) in the brain of largemouth bass at 0.5 ppm concentration (E. Oberdörster, 2004 *Environmental Health Perspectives*)
- Carbon SWNTs are hydrophobic and will likely associate strongly with sediments upon entry into the aquatic environment
- In sediments, these materials may cause toxicity to benthic, sediment ingesting organisms and may impact the disposition of persistent and bioaccumulative organic contaminants such as PCBs and PAHs

Study objectives

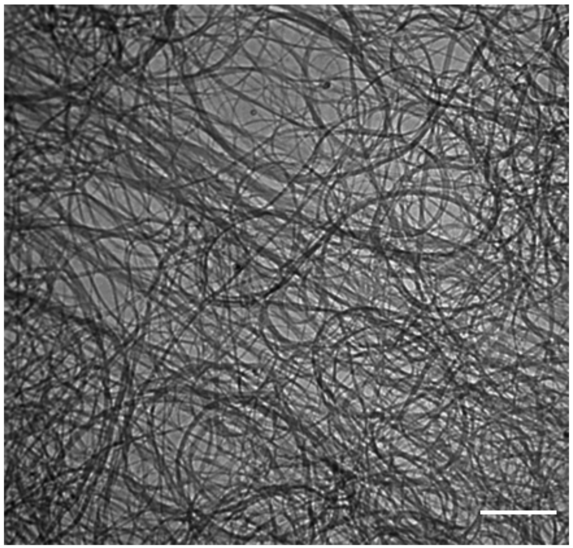
1. Determine factors controlling the fate of SWNTs in estuarine seawater, sediment, and sediment-ingesting organisms
2. Examine impact of SWNTs on the disposition of model organic contaminants in estuarine sediments
3. Determine whether the presence of SWNTs in estuarine sediments affects the bioavailability of model organic contaminants to suspension- and deposit-feeding estuarine invertebrates
4. Assess the toxicity of SWNTs to a model deposit-feeding estuarine invertebrate in seawater and /or in combination with estuarine sediments

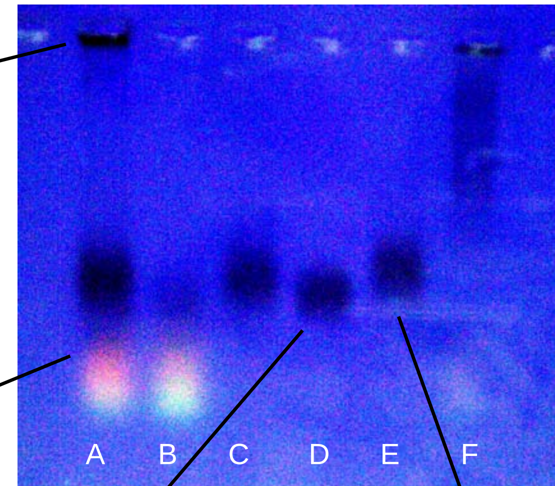
Synthesis and purification of ^{14}C-SWNT materials

Arc-discharge synthesis (^{14}C electrode dopant)

Oxidative treatment

Electrophoretic purification

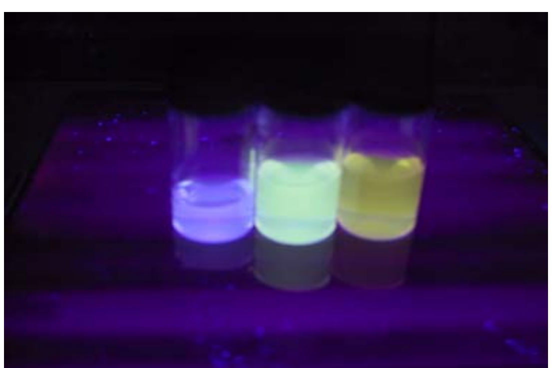


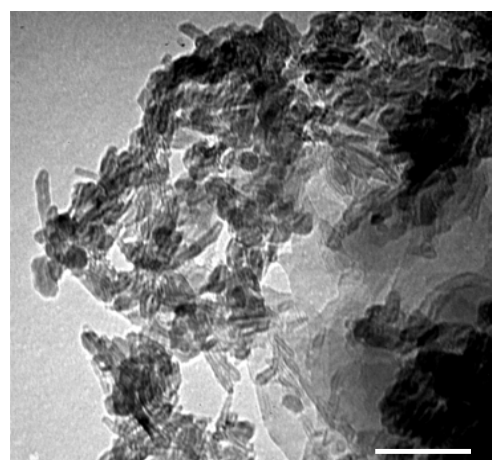


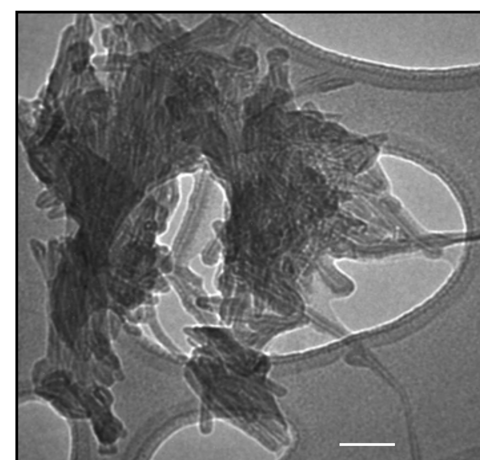
Purified SWNTs

Fluorescent impurities

Nano rods



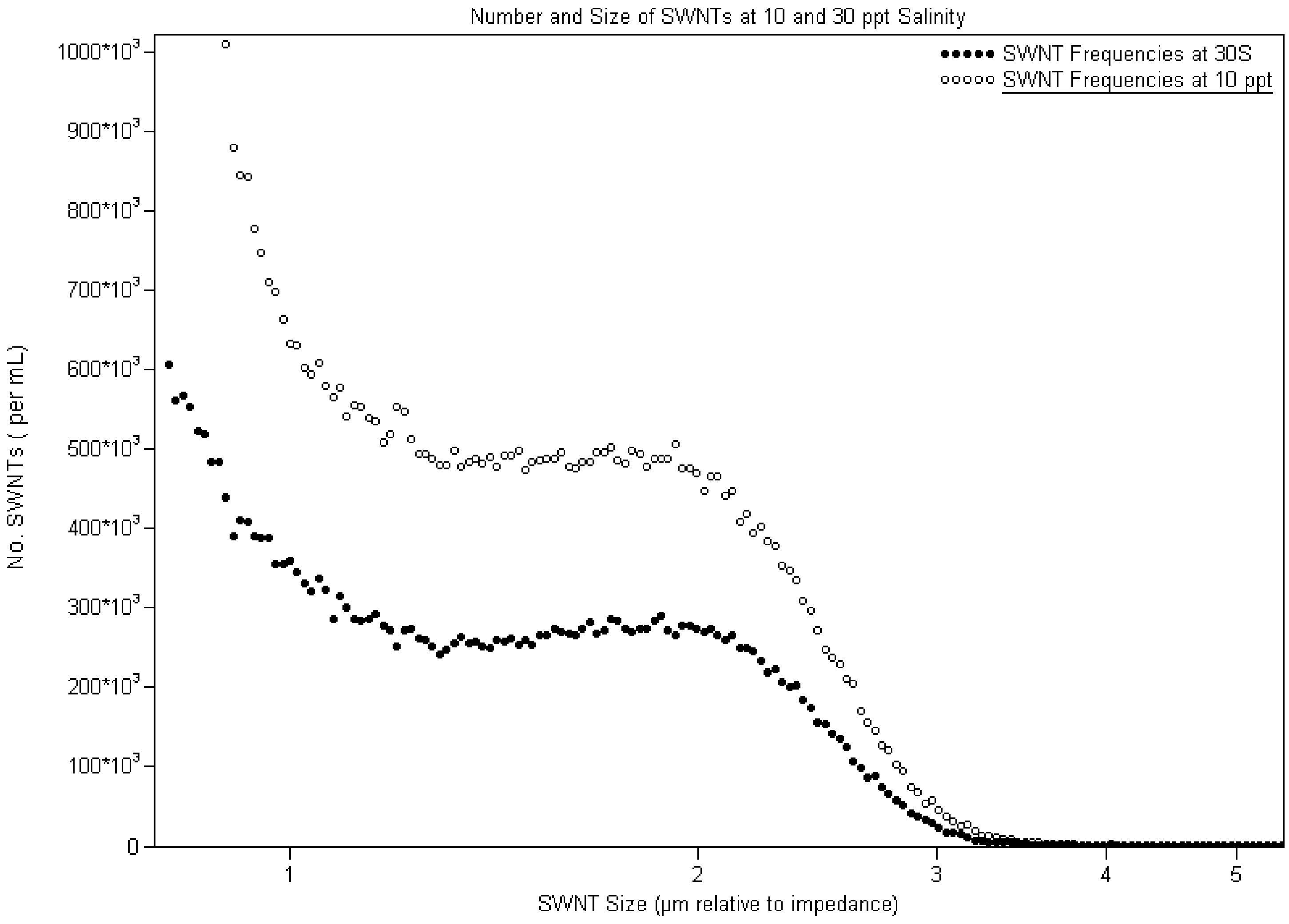




Experimental approach

- Utilize radiolabeled SWNT material to track sorption to sediments, flocculation, colloid formation under simulated estuarine conditions (salinity, DOM)
- Track sediment-associated ^{14}C-SWNTs through ingestion by deposit feeding organisms to assess bioaccumulation
- Use model hydrophobic organic contaminants to evaluate sorption potential of SWNTs and their impact on priority pollutant bioavailability in sediments
- Evaluate toxicity of SWNTs using a multiple-endpoint sediment toxicity bioassay developed in previous work for EPA

Size distribution of SWNT clusters in simulated estuarine seawater



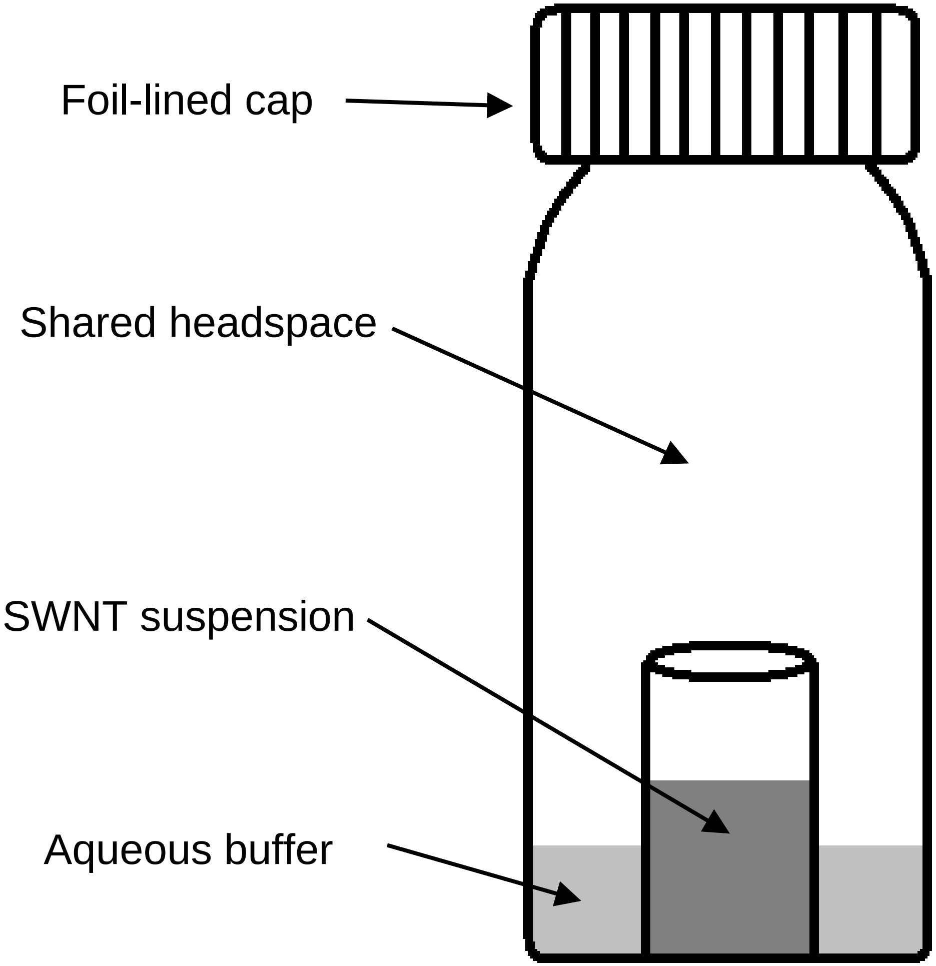
Evaluating sorption of HOCs to SWNTs using common headspace partitioning

Model sorbates:

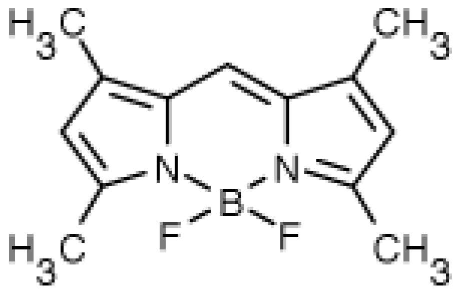
^{14}C-hexachlorobenzene

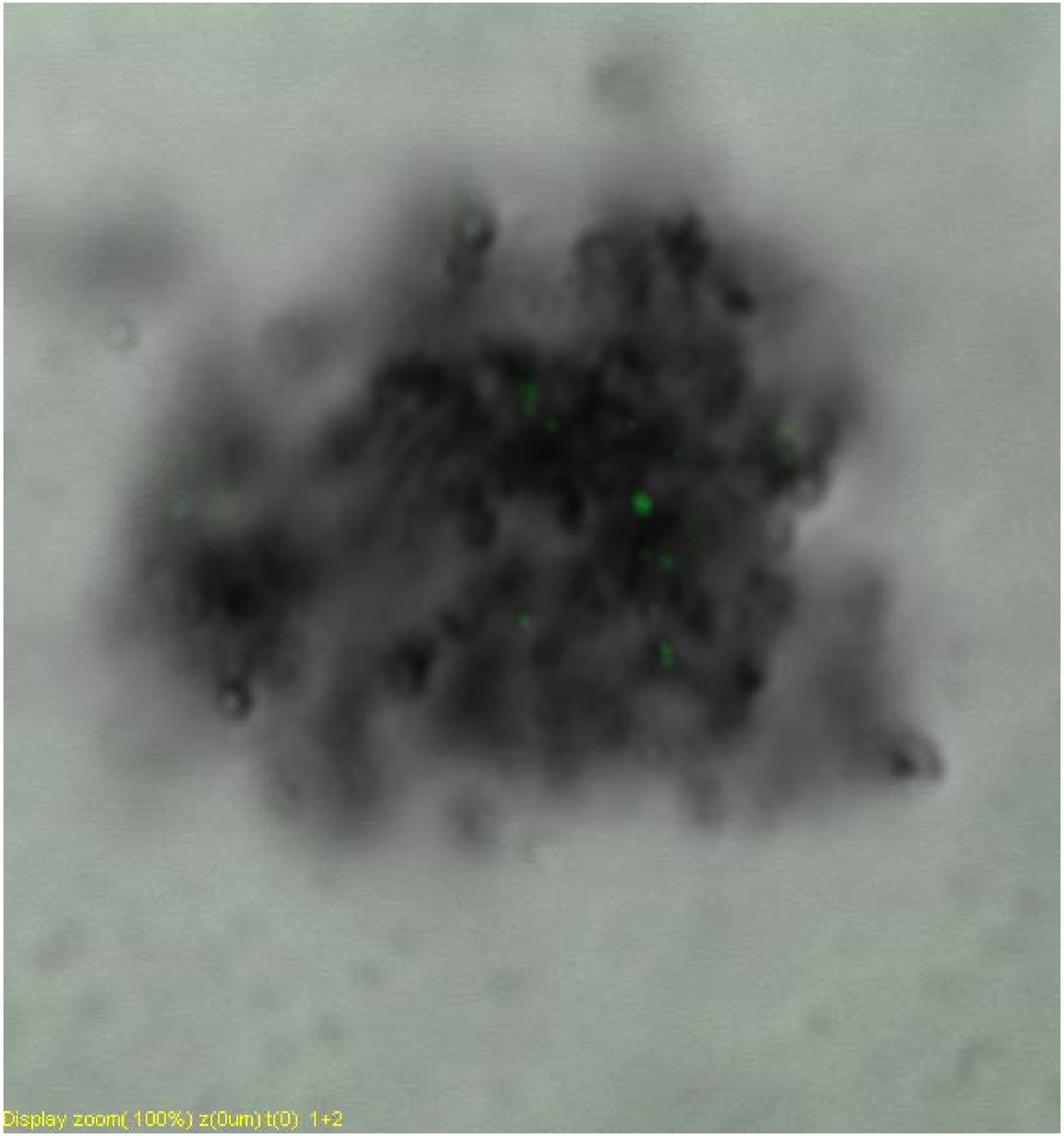
^{14}C-napthalene

$$K_d = \frac{(C_i - C_o) \times V_w}{C_o \times m_{SWNT}}$$



Confocal microscope image stack of a 6 μm SWNT cluster stained with BODIPY 505/515



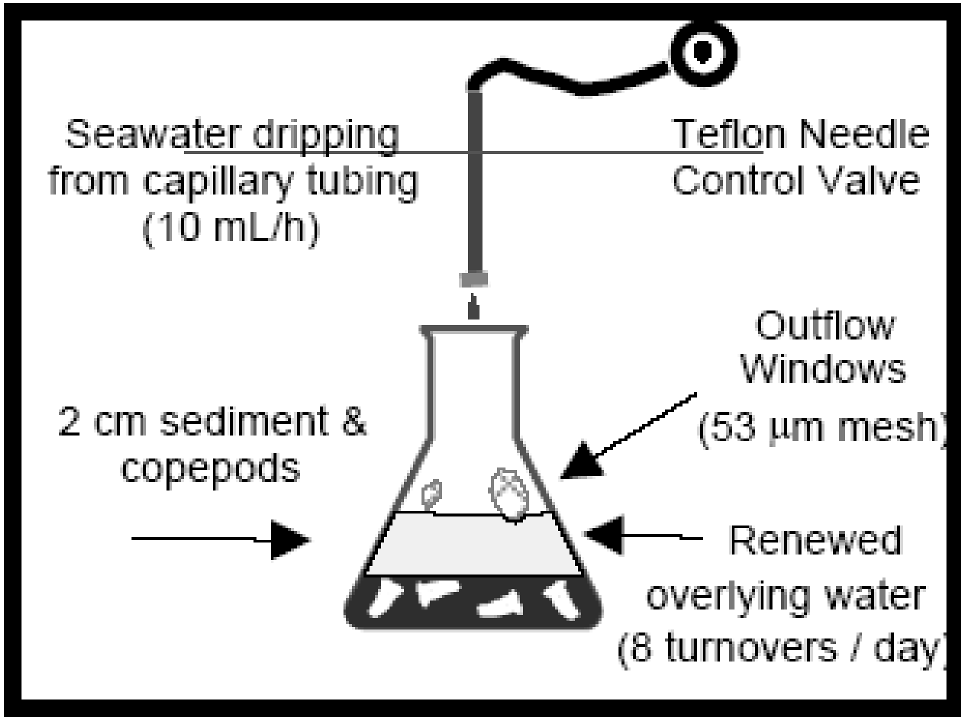


Sediment toxicity/bioaccumulation bioassay

Amphiascus

Streblospio

Bioassay Chamber Design

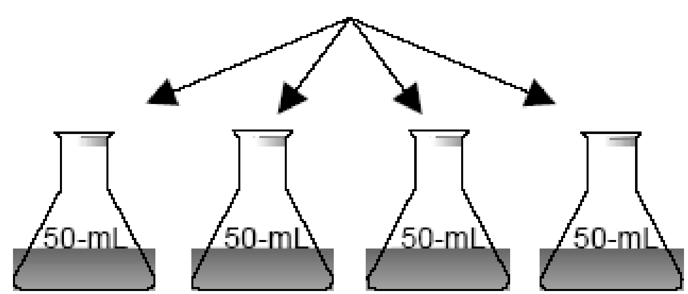


Copepod Lifecycle Bioassay Design & Setup

500 g pristine N. Inlet sediments press-sieved, amended with 1, 5, 10 mg-SWNT/g-sed, and loaded into teflon syringes

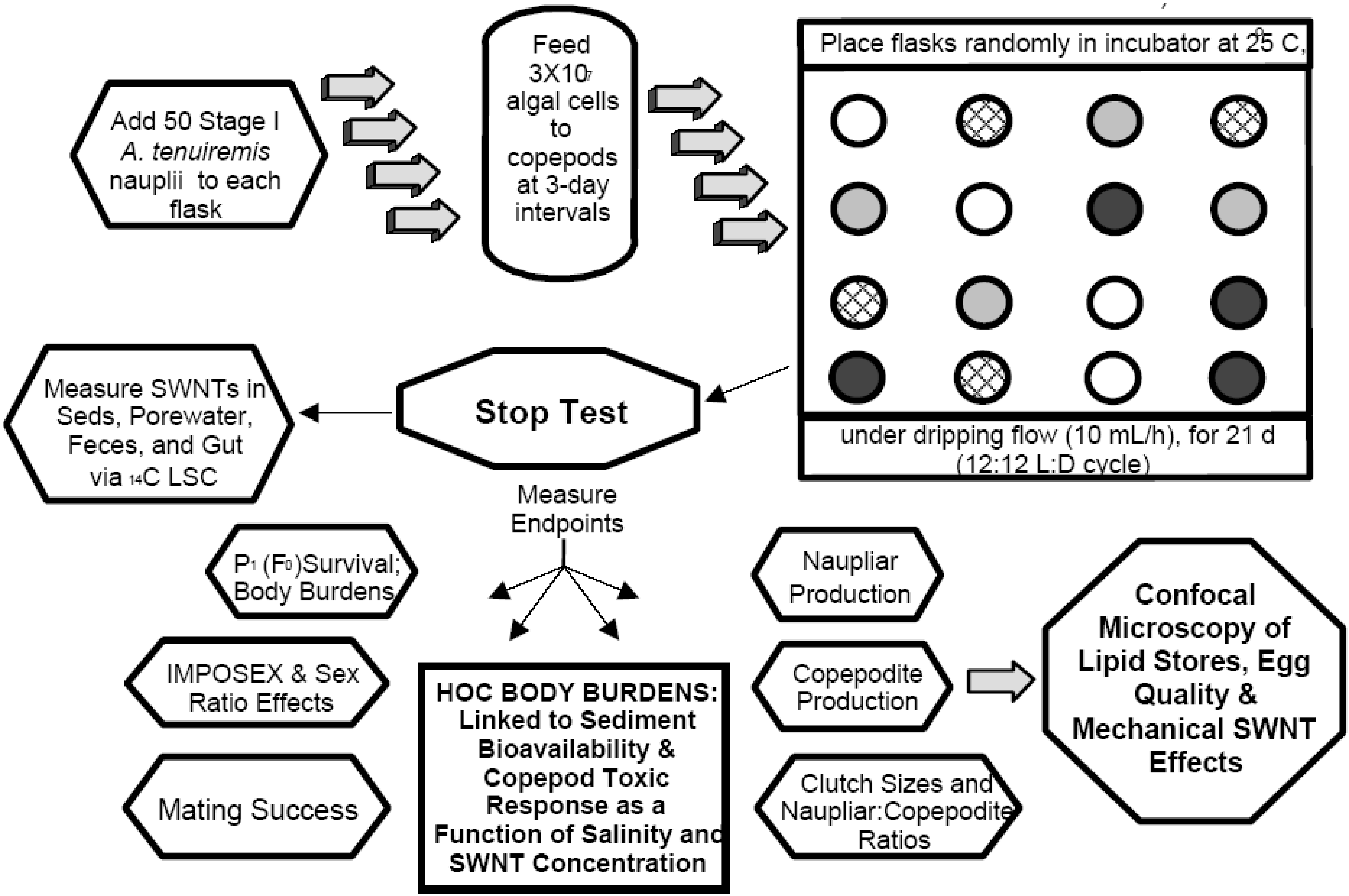
Remove 50 g SWNT:sediments per treatment for LSC verification of SWNT and HOC concentrations (n=4)

Distribute 12 mL aliquots to 4 experimental PTFE flasks per sediment:SWNT treatment in 30 mL of 10 or 30 ppt seawater



(4 replicates per sediment:SWNT treatment and control)

Bioassay endpoint selection



Expected benefits

- Fate tracking in estuarine sediments will inform about potential disposition of SWNTs discharged to the aquatic environment, useful in environmental exposure risk assessment
- Sorption and bioavailability studies will reveal the possible impact of SWNTs on the fate and effect of hydrophobic organic contaminants in estuarine sediments
- Toxicity studies will lead to increased understanding of the potential effects of SWNTs on trophically important estuarine invertebrates in sediments